11-7-2023

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Journal of the American Heart Association

ORIGINAL RESEARCH

Relationship of Race With Functional and Clinical Outcomes With the REHAB-HF Multidomain Physical Rehabilitation Intervention for Older Patients With Acute Heart Failure

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BACKGROUND: The REHAB-HF (Rehabilitation Therapy in Older Acute Heart Failure Patients) randomized trial demonstrated that a 3-month transitional, tailored, progressive, multidomain physical rehabilitation intervention improves physical function, frailty, depression, and health-related quality of life among older adults with acute decompensated heart failure. Whether there is differential intervention efficacy by race is unknown.

METHODS AND RESULTS: In this prespecified analysis, differential intervention effects by race were explored at 3 months for physical function (Short Physical Performance Battery [primary outcome], 6-Minute Walk Distance), cognition, depression, frailty, health-related quality of life (Kansas City Cardiomyopathy Questionnaire, EuroQoL 5-Dimension-5-Level Questionnaire) and at 6 months for hospitalizations and death. Significance level for interactions was $P \leq 0.1$. Participants (N=337, 97% of trial population) self-identified in near equal proportions as either Black (48%) or White (52%). The Short Physical Performance Battery intervention effect size was large, with values of 1.3 (95% CI, 0.4–2.1; $P=0.003$]) and 1.6 (95% CI, 0.8–2.4; $P<0.001$) in Black and White participants, respectively, and without significant interaction by race ($P=0.56$). Beneficial effects were also demonstrated in 6-Minute Walk Distance, gait speed, and health-related quality of life scores without significant interactions by race. There was an association between intervention and reduced all-cause rehospitalizations in White participants (rate ratio, 0.73 [95% CI, 0.55–0.98]; $P=0.034$) that appears attenuated in Black participants (rate ratio, 1.06 [95% CI, 0.81–1.41]; $P=0.66$; interaction $P=0.067$).

CONCLUSIONS: The intervention produced similarly large improvements in physical function and health-related quality of life in both older Black and White patients with acute decompensated heart failure. A future study powered to determine how the intervention impacts clinical events is required.

REGISTRATION: URL: https://www.clinicaltrials.gov. Identifier: NCT02196038.

Key Words: frailty ■ heart failure ■ personalized care ■ physical rehabilitation ■ social determinants of health

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This manuscript was sent to Sula Mazimba, MD, MPH, Associate Editor, for review by expert referees, editorial decision, and final disposition.

Supplemental Material is available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.123.030588

For Sources of Funding and Disclosures, see page 10.

JAHA is available at: www.ahajournals.org/journal/jaha

CLINICAL PERSPECTIVE

What Is New?

- In this prespecified analysis of the REHAB-HF (Rehabilitation Therapy in Older Acute Heart Failure Patients) trial, the 3-month transitional, tailored, progressive multidomain physical rehabilitation intervention produced similarly large improvements in physical function and health-related quality of life in older Black and White patients with acute decompensated heart failure.

What Are the Clinical Implications?

- This analysis demonstrates the potential generalizability and robustness of the intervention and also suggests that the protocol, inclusive of comprehensive adherence and retention strategies, was successful in supporting both Black and White patients with varying baseline health determinants.
- Though the trial was not powered for definitive conclusions from clinical events, the intervention appeared possibly associated with a differential effect on 6-month all-cause rehospitalization rates by race, suggesting the need for a larger follow-up study with robust racial and ethnic representation.

Nonstandard Abbreviations and Acronyms

ADHF	acute decompensated heart failure
HRQOL	health-related quality of life
REHAB-HF	Rehabilitation Therapy in Older Acute Heart Failure Patients
SPPB	Short Physical Performance Battery

Severe impairments in physical function, which are infrequently identified or addressed in routine heart failure (HF) clinical care, may contribute to the persistently poor outcomes associated with acute decompensated heart failure (ADHF). Prior interventions have primarily focused on pharmaceutical-based targets. The REHAB-HF (Rehabilitation Therapy in Older Acute Heart Failure Patients) trial demonstrated that a transitional, tailored, progressive multidomain physical rehabilitation intervention improved physical function, health-related quality of life (HRQOL), and depression in older adults hospitalized with ADHF, regardless of ejection fraction (EF) phenotype.[1,2] Whether there is differential efficacy of the intervention by race has not yet been explored.

Groups that have been historically marginalized in clinical practice and underrepresented in clinical studies are at increased risk for poor HF-related health outcomes. For example, across all age groups, Black individuals are more likely than White individuals to have an ADHF event, and death related to HF is significantly higher for Black compared with White individuals.[3–5] A prior REHAB-HF subgroup analysis stratified by race and sex found substantial differences in many baseline characteristics, notably that White men had less severely impaired walking function than 3 other groups (Black men, Black women, and White women) despite adjustments for EF category and educational level and traditional cardiovascular disease risk factors (age, body mass index, comorbidity).[6] In addition, White individuals were more likely to have the social support of living with a spouse or family member than Black individuals. Taken together, the differences found across these studies likely stem in part from inequities in social determinants of health such as health care policy and access, income level and economic stability, and neighborhood and built-environment quality. In turn, these disparities impact health-sustaining behaviors, health care usage, and HF self-management regimens and likely contribute to variable health outcomes. Related to the current study, there is the question of whether there is a variable response by race, a proxy for the constellation of socialized experiences, to the REHAB-HF intervention.[7]

There is currently limited literature exploring the effects of physical rehabilitation and exercise interventions by race in ADHF. In contrast, in patients who have established cardiovascular disease or are recovering from an acute cardiovascular disease event, non-White individuals have lower enrollment in and adherence to outpatient cardiac rehabilitation than White individuals, despite the well-described benefits associated with cardiac rehabilitation on long-term health outcomes.[8–11] Thus, evaluating whether the effects of physical rehabilitation interventions vary across racial groups in ADHF is a critical first step toward the end goal of appropriately personalizing care to reduce disparities and optimize outcomes.

METHODS

Study Design

Details regarding trial design,[12,13] interventional fidelity,[14] cross-sectional baseline characteristics by race and sex as well as EF phenotype,[6,15] overall trial results,[1] and EF subgroup analysis results[2] have been previously published. In brief, REHAB-HF was a randomized, controlled trial that examined a 3-month (12-week) transitional, tailored, progressive, one-on-one (interventionist : participant), multidomain physical

rehabilitation intervention (focused on strength, balance, mobility, and endurance) in a population of older individuals following hospitalization for ADHF that met its primary end point of improving the Short Physical Performance Battery (SPPB) at 3 months in the intervention group. When possible, intervention sessions began on an inpatient basis and continued to outpatient for 12 weeks, 3 days weekly, totaling 36 sessions. Of the 7 participating hospitals in North Carolina and Pennsylvania, 4 were academic and 3 were community based. All centers approved study enrollment through their respective institutional review boards. All participants provided informed consent. Data requests will be considered on a case-by-case basis by the REHAB-HF steering committee.

Participants

The study included 349 individuals aged ≥60 years hospitalized for ≥24 hours for ADHF, including both HF with preserved EF and HF with reduced EF. Additional inclusion criteria included the ability to ambulate 4 meters (with or without an assistive device), functional independence before admission, and an expectation of being discharged home. Key exclusion criteria included acute myocardial infarction; end-stage HF, including those on inotropic agents or who may be considered for advanced HF therapies in the next 6 months; severe valvular disease; advanced kidney disease defined by an estimated glomerular filtration rate ≤20 mL/min/1.73 m^2 or requiring dialysis; current enrollment in cardiac rehabilitation; or limitations with participation due to stroke, dementia, or other conditions.

In accordance with the US Office of Management and Budget minimum reporting standards for federally funded research, race and biological sex were self-reported. Due to small numbers and, as previously described,[6] individuals who participated in the study and self-reported a race other than White or Black were included in the trial but not in race-specific analyses (n=12): Asian (n=4, 1%), American Indian or Alaska Native (n=7, 2%), and no racial identification (n=1, <1%). Among participants selecting multiple races, individuals who selected Black were categorized as Black (n=6), whereas individuals who selected White and any race other than Black were classified as White (n=1). The Consolidated Standards of Reporting Trials checklist for the primary trial and diagrams for the primary trial and current analysis are included in Figures S1 and S2.

Study Variables

Data collection was performed by individuals unaware of trial-group assignments before hospital discharge and at 3 months. The primary end point was physical function as measured by the SPPB, which has been validated in frail, older populations to predict numerous outcomes, including death.[16] It comprises 3 components, including static standing balance; 4-meter gait speed; and time to perform 5 chair stands scored from 0 to 4 with a total score of 0 to 12, with higher scores indicating better physical function. Scores <10 are considered at risk for physical disability.[17]

Secondary outcomes captured at 3 months included physical function as assessed by 6-Minute Walk Distance[18]; heart failure symptoms and quality of life by Kansas City Cardiomyopathy Questionnaire[19]; and general quality of life by the EuroQol 5-Dimension-5-Level Questionnaire; depression by the Geriatric Depression Scale-15[20]; cognitive function by the Montreal Cognitive Assessment[21]; and Frailty by the Fried Frailty Phenotype.[22] See Table S1 for functional outcome variables, numerical ranges, and associated prognostic cutoffs. Additionally, rehospitalization, rehospitalization days, death, and falls were collected at 6 months through interviews and electronic health record review.

Statistical Analysis

Baseline characteristics were reported as mean (SD) or median (interquartile range) for continuous variables and frequency (percentage) for categorical variables. Differences in characteristics between White and Black participants were compared using *t*-tests and chi-square tests for continuous and categorical variables, respectively. To evaluate the potential moderating effect of race on the effect of the intervention on 3-month outcomes (SPPB total and component scores, Montreal Cognitive Assessment, Geriatric Depression Scale-15, Fried Frailty Criteria, 6-Minute Walk Distance, gait speed, Kansas City Cardiomyopathy Questionnaire, and EuroQol 5-Dimension-5-Level Questionnaire), general linear models that included indicator variables for intervention, race, and their interaction were used. All analyses were adjusted for 2 stratification factors used for randomization, EF category of <45% or ≥45% and clinical site as well as 2 other established independent predictors of HF outcomes—baseline age and sex—as in other analyses of REHAB-HF trial data. Furthermore, as baseline age and sex differed by race and EF trended to differ by race, they could be confounders in the association of race with outcomes. We used least square means to estimate the effects of the intervention in race groups, and effect sizes were reported with 95% CIs.

The moderating effect of race on the effect of the intervention on 6-month clinical outcomes was assessed using Poisson regression for all-cause rehospitalizations, HF rehospitalizations, and deaths; negative binomial regression for facility-free days and hospitalized days due to overdispersion; and logistic regression for the presence of any falls during the study. All analyses were adjusted for age, sex, EF category, and clinical

Table 1. Baseline Characteristics of Race Groups by Treatment Arm

Characteristics	White				Black				Between-race *P* value
	All (n=175)	Rehabilitation (n=93)	Attention control (n=82)	Within-group *P* value	All (n=162)	Rehabilitation (n=76)	Attention control (n=86)	Within-group *P* value	
Age, y	74.6 (8.3)	74.9 (8.6)	74.3 (8.1)	0.61	70.4 (7.2)	70.8 (7.5)	70.2 (7.0)	0.61	<0.0001
Female	76 (43.4)	37 (39.8)	39 (47.6)	0.30	103 (63.6)	47 (61.8)	56 (65.1)	0.67	<0.001
Ejection fraction ≥45%	101 (57.7)	52 (55.9)	49 (59.8)	0.61	77 (47.5)	39 (51.3)	38 (44.2)	0.06	0.061
NYHA class									
I–II	32 (18.3)	16 (17.2)	16 (19.5)	0.69	31 (19.1)	16 (21.1)	15 (17.4)	0.67	0.24
III	102 (58.3)	57 (61.3)	45 (54.9)		81 (50)	39 (51.3)	42 (48.8)		
IV	41 (23.4)	20 (21.5)	21 (25.6)		50 (30.9)	21 (27.6)	29 (33.7)		
BMI, kg/m^2	31.9 (8.6)	32.3 (8.5)	31.4 (8.7)	0.50	33.8 (8.2)	33.6 (7.8)	33.9 (8.6)	0.83	0.040
BNP, pg/mL (n=197)*	516 (278–1041)	583 (306–1038)	500 (193–1104)	0.27	669 (374–1292)	689 (430–1089)	642 (304–1381)	0.85	0.25
N-terminal proBNP, pg/mL (n=116)*	3549 (1939–6983)	3688.0 (1969–9074)	3464.0 (1793–4547)	0.49	2796 (1425–5358)	3131 (1492–6640)	2488 (1357–5174)	0.27	0.37
Index hospital LOS, days	5.0 (3.0–7.0)	5.0 (3.0–7.0)	5.0 (3.0–7.0)	0.37	4.0 (3.0–7.0)	4.0 (3.0–7.0)	5.0 (3.0–7.0)	0.19	0.17
Hospitalization in past 6 mo	69 (39.4)	34 (36.6)	35 (42.7)	0.41	80 (49.4)	38 (50.0)	42 (48.8)	0.88	0.066
HF Hospitalization in past 6 mo	40 (22.9)	20 (21.5)	20 (24.4)	0.70	45 (27.8)	20 (26.3)	25 (29.1)	0.82	0.18
Fall in past 3 mo‡	22 (14.8)	10 (12.8)	12 (16.9)	0.49	21 (16.2)	13 (20.6)	8 (11.9)	0.18	0.75
Comorbidities									
Total number	5.4 (2.0)	5.5 (2.2)	5.2 (1.8)	0.37	5.0 (1.8)	5.2 (1.9)	4.8 (1.8)	0.13	0.043
Hypertension	155 (88.6)	81 (87.1)	74 (90.2)	0.51	155 (95.7)	73 (96.1)	82 (95.3)	0.83	0.016
History of MI	34 (19.4)	16 (17.2)	18 (22.0)	0.43	25 (15.4)	12 (15.8)	13 (15.1)	0.91	0.33
History of coronary revascularization	70 (40)	38 (40.9)	32 (39.0)	0.80	28 (17.3)	15 (19.7)	13 (15.1)	0.44	<0.0001
Atrial fibrillation	109 (62.3)	55 (59.1)	54 (65.9)	0.36	61 (37.7)	30 (39.5)	31 (36.0)	0.65	<0.0001
Diabetes	84 (48)	52 (55.9)	32 (39.0)	0.026	94 (58)	48 (63.2)	46 (53.5)	0.21	0.066
Hyperlipidemia	114 (65.1)	58 (62.4)	56 (68.3)	0.41	109 (67.3)	48 (63.2)	61 (70.9)	0.29	0.68
COPD	52 (29.7)	30 (32.3)	22 (26.8)	0.43	43 (26.5)	23 (30.3)	20 (23.3)	0.31	0.52
CKD	55 (31.4)	28 (30.1)	27 (32.9)	0.69	57 (35.2)	29 (38.2)	28 (32.6)	0.46	0.46
Stroke	21 (12)	9 (9.7)	12 (14.6)	0.31	27 (16.7)	14 (18.4)	13 (15.1)	0.57	0.22
PVD	23 (13.1)	16 (17.2)	7 (8.5)	0.09	17 (10.5)	11 (14.5)	6 (7.0)	0.12	0.45
Arthritis, muscle/joint pain, CTD	81 (46.3)	46 (49.5)	35 (42.7)	0.37	68 (42)	36 (47.4)	32 (37.2)	0.19	0.44
History of cancer	44 (25.1)	28 (30.1)	16 (19.5)	0.11	28 (17.3)	11 (14.5)	17 (19.8)	0.37	0.079
Sleep-disordered breathing	57 (32.6)	35 (37.6)	22 (26.8)	0.13	65 (40.1)	32 (42.1)	33 (38.4)	0.63	0.15
Depression	44 (25.1)	22 (23.7)	22 (26.8)	0.63	17 (10.5)	7 (9.2)	10 (11.6)	0.61	<0.001

(*Continued*)

Table 1. Continued

Characteristics	White				Black				
	All (n=175)	Rehabilitation (n=93)	Attention control (n=82)	Within-group *P* value	All (n=162)	Rehabilitation (n=76)	Attention control (n=86)	Within-group *P* value	Between-race *P* value
Dementia or cognitive impairment	4 (2.3)	2 (2.2)	2 (2.4)	0.90	5 (3.1)	3 (3.9)	2 (2.3)	0.55	0.65
Urinary incontinence†	22 (15)	12 (15.8)	10 (14.1)	0.77	17 (13.2)	6 (9.5)	11 (16.7)	0.23	0.67

BMI indicates body mass index; BNP, B-type natriuretic peptide; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CTD, connective tissue disease; HF, heart failure; LOS, length of stay; MI, myocardial infarction; N-terminal proBNP, N-terminal pro-B-type natriuretic peptide; NYHA, New York Heart Association; and PVD, peripheral vascular disease.

*Presented as n (%), mean (SD), or median (interquartile range).

†Data collected in Attention Control=137, Rehabilitation Intervention=139.

‡Data collected in Attention Control=138, Rehabilitation Intervention=141.

site. All-cause rehospitalization was also adjusted for baseline SPPB score as prespecified. Effect sizes for White and Black participants were summarized as rate ratio for count-based outcomes and odds ratio for binary outcomes. We also performed a sensitivity analysis to investigate the effect of baseline hospitalizations on the 6-month all-cause rehospitalizations. A stratified analysis was conducted to evaluate the moderating effect of race on the effect of the intervention in patients with and without any baseline hospitalization.

A *P* value of <0.05 was prespecified as statistically significant for overall comparisons. The interaction between race and the intervention was prespecified as significant if *P*<0.10. Due to the hypothesis-generating nature of the analysis, there was no correction for multiple comparisons.

RESULTS

Baseline Characteristics

Of the 349 participants included in the REHAB-HF trial, 337 self-identified as Black (48%; 76 intervention, 86 control) or White (52%; 93 intervention, 82 control) individuals. Tables 1 and 2 present the baseline characteristics by race as well as treatment arm. Black participants tended to be younger than White participants (mean age, 70.8 ± 7.5 versus 74.6 ± 8.3 years; *P*<0.001) and to have a higher body mass index (33.6 ± 8.2 versus 31.9 ± 8.6 kg/m^2; *P*=0.040). Black participants were more likely to be women (64% versus 43%; *P*<0.001).

Overall, comorbidity burden was high across both races. Black participants had a lower total comorbidity count than White participants (5.0 versus 5.4; *P*=0.043; Table 1). Black participants were more likely to have hypertension (96% versus 87%; *P*=0.016) and were less likely to have atrial fibrillation (38% versus 62%; *P*<0.001) and to have a diagnosis of depression (11% versus 25%; *P*<0.001). Though Black and White participants had a similar prevalence of myocardial infarction, Black participants were less likely to have prior revascularization (17% versus 40%; *P*<0.001). Medical and device therapies for HF were evenly distributed between both races (Table 2). There was a nonsignificant trend for Black participants to have had a hospitalization in the preceding 6 months compared with White participants (49% versus 39%; *P*=0.066; Table 1). This appeared to be due to more non-HF hospitalizations as there was no difference in baseline HF hospitalizations between Black and White individuals (17% versus 22%; *P*=0.18; Table 1).

Adherence and Retention Metrics

Of the 169 participants randomized to intervention, 11 died before completing the intervention (6 Black participants, 5 White participants), 13 dropped from the

Table 2. Baseline Medical and Device Therapies of Race Groups by Treatment Arm

Characteristics	White				Black				Between-race *P* value
	All (n=175)	Rehabilitation (n=93)	Attention control (n=82)	Within-group *P* value	All (n=162)	Rehabilitation (n=76)	Attention control (n=86)	Within-group *P* value	
Loop diuretic	164 (94.3)	88 (94.6)	76 (93.8)	0.83	150 (92.6)	68 (89.5)	82 (95.3)	0.15	0.54
Beta blocker	134 (77)	73 (78.5)	61 (75.3)	0.62	133 (82.1)	61 (80.3)	72 (83.7)	0.25	0.25
Angiotensin-converting enzyme inhibitors	61 (35.1)	32 (34.4)	29 (35.8)	0.85	65 (40.1)	31 (40.8)	34 (39.5)	0.34	0.34
Angiotensin II receptor blockers	36 (20.7)	19 (20.4)	17 (21.0)	0.93	37 (22.8)	18 (23.7)	19 (22.1)	0.63	0.63
Aldosterone antagonists	34 (19.5)	19 (20.4)	15 (18.5)	0.75	28 (17.3)	9 (11.8)	19 (22.1)	0.09	0.59
Digoxin	10 (5.7)	6 (6.5)	4 (4.9)	0.67	8 (4.9)	1 (1.3)	7 (8.1)	0.74	0.74
Insulin	47 (27)	27 (29.0)	20 (24.7)	0.52	47 (29)	25 (32.9)	22 (25.6)	0.31	0.68
Oral diabetic agents	41 (23.6)	28 (30.1)	13 (16.0)	0.029	41 (25.3)	22 (28.9)	19 (22.1)	0.32	0.71
Implantable cardioverter-defibrillator	28 (16)	16 (17.2)	12 (14.6)	0.64	29 (17.9)	13 (17.1)	16 (18.6)	0.80	0.64
Biventricular pacemaker	16 (9.1)	9 (9.7)	7 (8.5)	0.79	8 (4.9)	3 (3.9)	5 (5.8)	0.58	0.13

*Presented as n (%), mean (SD), or median (interquartile range).

study (6 Black participants, 7 White participants), and 16 discontinued the intervention but contributed to the primary outcome assessment (10 Black participants, 6 White participants). Overall intervention retention was 82% (ie, participants who did not drop from the study or die). There were no significant differences between Black and White participants in adherence to the intervention. Of all participants retained in the intervention, Black and White participants completed 24.8±1.5 sessions (69±4% adherence) and 27.0±1.1 sessions (75±3% adherence), respectively (*P*=0.24). After accounting for sessions missed due to illness and medical appointments, intervention adherence rates were 76±4% and 82±3% for Black and White participants, respectively (*P*=0.26).

Three-Month Functional Outcomes

Functional outcomes at 3 months are delineated by race in Figure 1 and Table 3. Improvements in the primary trial outcome, SPPB, were similarly large in both Black and White participants with respective differences between mean intervention and control of 1.3 (95% CI, 0.4–2.1) units and 1.6 (95% CI, 0.8–2.4) units (both *P*<0.01) and no significant interaction (*P*=0.56). Additionally, there were large improvements in gait speed in both Black and White participants with mean intervention and control value differences of 0.12 m/s (95% CI, 0.06–0.18; *P*<0.001) and 0.12 m/s (95% CI, 0.06–0.18; *P*<0.001), respectively, and no significant interaction (*P*=0.96).

There were no significant interactions in other 3-month outcomes (Figure 1, Table 3). These included 6-Minute Walk Distance with mean differences between study groups in respective Black and White participants with gains of 31.1 m (95% CI, –1.7 to 64.0; *P*=0.06) versus 37.6 m (95% CI, 6.1–69.1; *P*=0.020; interaction *P*=0.78). There were no significant differences in HRQOL as captured by the Kansas City Cardiomyopathy Questionnaire–Overall Summary Score with a difference in mean intervention and control values of 7.6 (95% CI, 0.1–15.2, *P*=0.05) for Black participants and 6.3 (95% CI, –1.0 to 13.6; *P*=0.09) for White participants (interaction *P*=0.81). A similar pattern was observed for EuroQol 5-Dimension-5-Level Questionnaire utility weights with a difference of mean intervention and control values of 6.3 (95% CI, –0.7 to 13.3; *P*=0.08) for Black participants and 7.5 (95% CI, 0.8–14.3; *P*=0.029) for White participants (interaction *P*=0.81). Differences between mean values for the intervention and control groups among Black and White patients on cognition, depression, and frailty are reported in Table 3.

Six-Month Clinical Events

There were no significant interactions between study groups and race in 6-month HF rehospitalization, all-cause death, rehospitalization and death, or injurious falls (Figure 1, Table 4). There was a significant interaction (*P*=0.067) in the rate ratios of all-cause rehospitalization in Black versus White participants with respective rate ratios of 1.06 (95% CI, 0.81–1.41; *P*=0.66) versus 0.73 (95% CI, 0.55–0.98; *P*=0.034). All-cause rehospitalization rates were similar among Black participants in both the intervention and control groups (1.38 and 1.24) as well as the White participants in the control group (1.33), while the rate was lower among White participants in the intervention group (0.98). Given that the percentage of Black participants

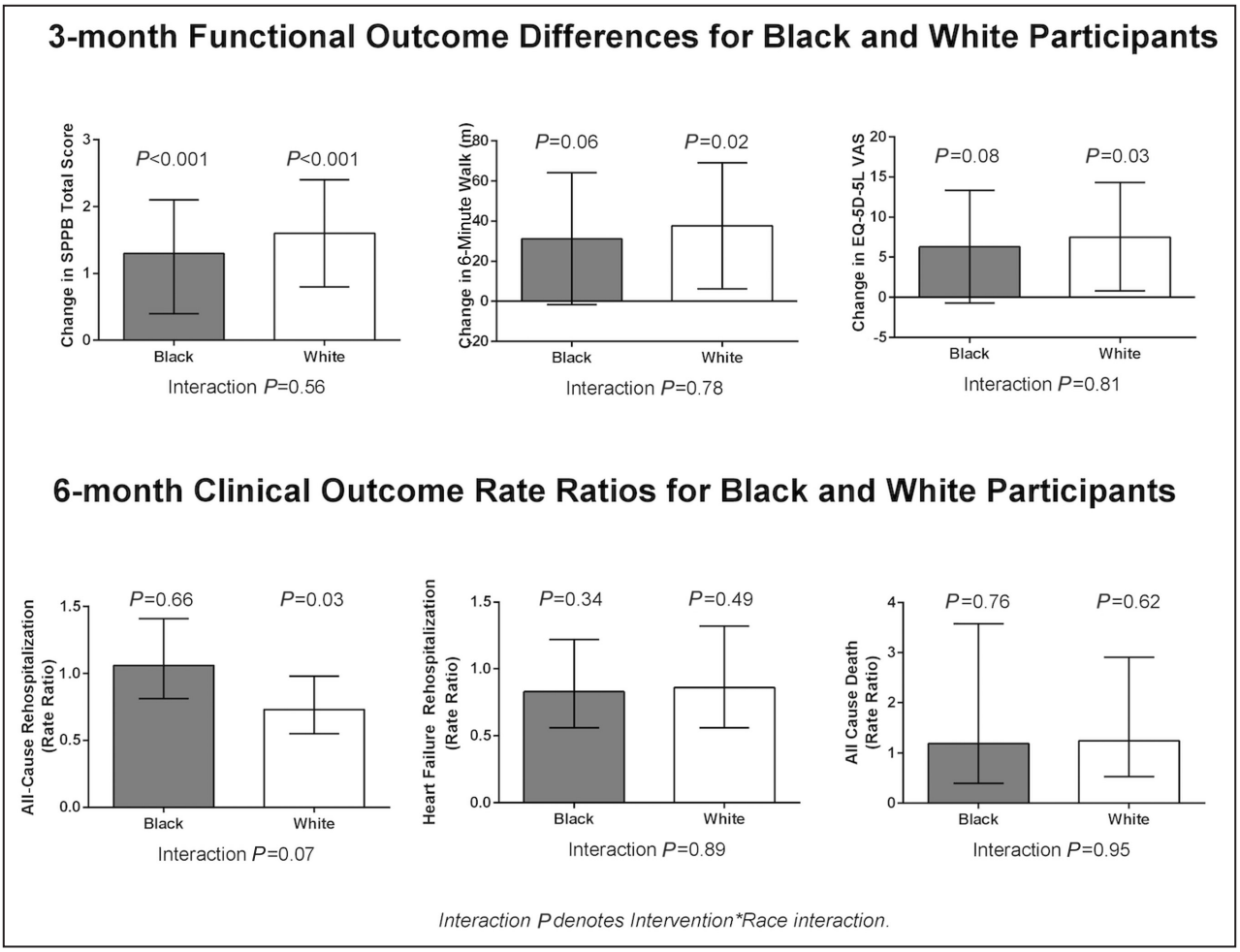

Figure 1. Functional outcome differences for Black and White participants.
Three-month functional outcomes and 6-month clinical outcomes for Black and White participants. Bars represent intervention vs control effect sizes (95% CI error bars). Interaction *P* values below each panel represent intervention*race interaction.

hospitalized within 6 months before baseline showed a nonsignificant trend to be higher than White participants (49% versus 39%; *P*=0.066), an additional analysis of all-cause rehospitalizations was performed examining the effects of recent baseline hospitalization. The results did not reveal significant variations in intervention effects on those with prior hospitalization for Black (Rate Ratio, 0.77 [95% CI, 0.52–1.14]; *P*=0.20) or White participants (RR, 1.15 [95% CI, 0.81–1.62]; *P*=0.43) or an interaction between the study intervention and race (*P*=0.14). Similar patterns were observed in participants without a hospitalization at baseline.

DISCUSSION

Key Findings

In this prespecified secondary analysis of the multicenter REHAB-HF trial, the innovative, 3-month transitional, tailored, progressive multidomain physical rehabilitation intervention in older adults with ADHF had similar adherence rates and produced similarly large improvements across multiple measures of physical function, including the primary trial outcome SPPB, and HRQOL for Black and White individuals, despite variable baseline characteristics. Although the trial was not sufficiently powered to draw definitive conclusions from clinical events, the intervention appeared potentially associated with lower 6-month all-cause rehospitalization rates in White participants, supporting the need for larger follow-up studies with robust recruitment of racial and ethnic diversity. Overall, this analysis demonstrates the potential generalizability and robustness of the intervention regardless of race and also suggests that the protocol, inclusive of comprehensive effective adherence and retention strategies across races, was successful in overcoming baseline demographic, social, and physical health-determinant differences between Black and White participants.

Table 3. Analysis of 3-Month Functional Outcomes by Race

	White				Black				Intervention by race interaction, *P* value
	Rehabilitation intervention (n=93)	Attention control (n=82)	Difference (95% CI)	*P* value	Rehab intervention (n=76)	Attention control (n=86)	Difference (95% CI)	*P* value	
Primary outcome									
SPPB	8.1 (0.3)	6.5 (0.3)	1.6 (0.8 to 2.4)	<0.001	8.0 (0.3)	6.7 (0.3)	1.3 (0.4 to 2.1)	0.003	0.56
Balance score	3.1 (0.1)	2.7 (0.1)	0.4 (0.1 to 0.8)	0.024	3.2 (0.2)	3.0 (0.2)	0.3 (–0.1 to 0.7)	0.15	0.61
4-m gait speed score	3.1 (0.1)	2.5 (0.1)	0.6 (0.3 to 0.9)	<0.001	2.8 (0.1)	2.5 (0.1)	0.3 (0.0 to 0.6)	0.08	0.16
Chair rise score	1.9 (0.1)	1.4 (0.1)	0.5 (0.1 to 0.8)	0.007	2.1 (0.2)	1.3 (0.1)	0.8 (0.4 to 1.2)	<0.001	0.21
Secondary outcomes									
MoCA	23.3 (0.5)	23.4 (0.5)	–0.1 (–1.2 to 1.1)	0.87	21.6 (0.5)	22.1 (0.5)	–0.6 (–1.7 to 0.6)	0.35	0.58
GDS-15	3.0 (0.3)	3.7 (0.3)	–0.7 (–1.5 to 0.1)	0.10	3.6 (0.3)	4.3 (0.3)	–0.6 (–1.5 to 0.2)	0.15	0.91
Fried Frailty Criteria	1.4 (0.1)	1.7 (0.1)	–0.3 (–0.6 to 0.1)	0.10	1.5 (0.1)	1.8 (0.2)	–0.3 (–0.6 to 0.1)	0.13	0.98
6MWD	286.9 (12.7)	249.3 (13.8)	37.6 (6.1 to 69.1)	0.020	292.0 (14.2)	260.8 (13.9)	31.1 (–1.7 to 64.0)	0.06	0.78
Gait speed, m/sec	0.84 (0.02)	0.72 (0.03)	0.12 (0.06 to 0.18)	<0.001	0.79 (0.03)	0.67 (0.02)	0.12 (0.06 to 0.18)	<0.001	0.96
KCCQ-CSS	71.3 (2.9)	66.2 (3.1)	5.1 (–2.2 to 12.4)	0.17	66.1 (3.1)	60.2 (3.0)	5.9 (–1.7 to 13.5)	0.13	0.88
KCCQ-OSS	71.6 (2.9)	65.3 (3.0)	6.3 (–1.0 to 13.6)	0.09	66.5 (3.1)	58.9 (3.0)	7.6 (0.1 to 15.2)	0.05	0.81
EQ-5D-5L	72.3 (2.7)	64.8 (2.8)	7.5 (0.8 to 14.3)	0.029	71.1 (2.9)	64.7 (2.8)	6.3 (–0.7 to 13.3)	0.08	0.81

Data are presented as means (SE) and differences (95% CI). All analyses were adjusted for age, sex, ejection fraction category, and clinical site.

6MWD, 6-Minute Walk Distance; CSS, Clinical Summary Score; EQ-5D-5L, EuroQol 5-Dimension 5-Level Questionnaire GDS-15, Geriatric Depression Scale-15; HRQOL, Health-Related Quality of Life; KCCQ, Kansas City Cardiomyopathy Questionnaire; MoCA, Montreal Cognitive Assessment; OSS, Overall Summary Score; SBBP, Short Physical Performance Battery.

Table 4. Analysis of 6-Month Clinical Outcomes by Race

	White				Black				Intervention by race interaction, *P* value
	Rehabilitation intervention (n=93)	Attention control (n=82)	Rate ratio (95% CI)	*P* value	Rehabilitation intervention (n=76)	Attention control (n=86)	Rate ratio (95% CI)	*P* value	
Secondary outcomes									
All-cause rehospitalization	84 (0.98)	104 (1.33)	0.73 (0.55–0.98)	0.034	100 (1.38)	102 (1.24)	1.06 (0.81–1.41)	0.66	0.067
HF rehospitalization	41 (0.48)	44 (0.56)	0.86 (0.56–1.32)	0.49	45 (0.62)	59 (0.72)	0.83 (0.56–1.22)	0.34	0.89
All-cause death	13 (0.15)	9 (0.11)	1.24 (0.53–2.91)	0.62	7 (0.10)	6 (0.07)	1.19 (0.40–3.58)	0.76	0.95
Rehospitalizationand death	97 (1.13)	113 (1.44)	0.79 (0.60–1.04)	0.09	107 (1.48)	108 (1.31)	1.06 (0.81–1.38)	0.69	0.14
Falls*	25 (0.27)	32 (0.39)	0.59 (0.31–1.13)	0.11	21 (0.28)	29 (0.34)	0.72 (0.36–1.41)	0.34	0.70

Data are presented as counts (6-mile rate) and rate ratio (95% CI) except *count (proportion) and odds ratio (95% CI). All analyses were adjusted for age, sex, ejection fraction category, and clinical site. All-cause rehospitalization was also adjusted for baseline SPPB score as prespecified.

HF indicates heart failure; and SBBP, Short Physical Performance Battery.

Impact of Personalized Care on Outcomes

Population health level data indicate that both sociodemographic and physical characteristics can predispose Black individuals to a higher incidence and prevalence of HF as well as a worse prognosis compared with White individuals.[23] One of the most significant risk factors for HF is hypertension, which is more common in the Black population and was reflected in our sample.[3] Likewise, in this trial, Black participants were younger and had higher body mass index, on average, and were less likely to have received coronary revascularization compared with White participants.[24,25] Furthermore, we previously reported variations in the social living situation and the severity of baseline functional impairments across race and sex.[6,26–28] However, despite the differences in baseline characteristics, there were similar intervention adherence rates, and the intervention produced similarly large improvements in physical function and HRQOL in both Black and White participants, corroborating and extending findings from exercise studies in chronic stable HF (Figure 2).[8,29]

Social and functional determinants of health are increasingly acknowledged for their impact on cardiovascular outcomes.[30] Indeed, 1 study examining Black individuals attending cardiac rehabilitation demonstrated improved coping efficacy and health benefits in those with greater social support.[31] The REHAB-HF protocol provided personalization of care by using tailored adherence strategies designed to address the specific social and functional determinants of health needs of the participants that would reduce barriers to trial participation and self-management of exercise.[12,14,32] For instance, a home and built-environment assessment was performed to support exercise safety and independence in the participant's home and community. Transportation support was provided to those who otherwise were unable to reach the outpatient facility. Strategies such as these led to similarly high intervention session adherence and fidelity across race, resulting in correspondingly large improvements in functional outcomes.[32] Our results not only underscore opportunities for the intervention to improve physical function and HRQOL but also to address sociodemographic variables that limit optimal participation in care and contribute to variable health outcomes for Black versus White individuals. However, the difference in 6-month all-cause rehospitalization between Black and White individuals (49% in Black versus 39% in White; P=0.066) was not explained by adherence rates or by variations in past hospitalizations at baseline, suggesting potential contributions of unmeasured or unaddressed social determinants of health.

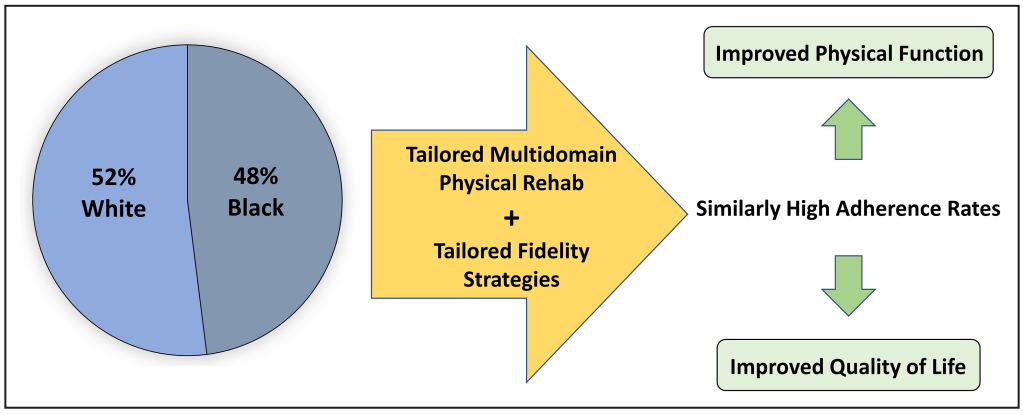

Figure 2. Relationship of race with outcomes in the REHAB-HF population.
Despite differences in baseline characteristics across a diverse sampling of Black and White participants, multidomain physical rehabilitation and intervention fidelity strategies personally tailored to the participant's physical and social health determinants resulted in similarly high intervention adherence rates and produced large improvements in physical function and health-related quality of life. REHAB-HF indicates Rehabilitation Therapy in Older Acute Heart Failure Patients.

Strengths and Limitations

Strengths of the current study include the randomized, controlled trial design; assessment of an innovative, early, transitional, tailored, and progressive multidomain physical rehabilitation intervention for vulnerable, high-risk older patients with ADHF; and strong representation of Black participants (48% of participants). Contextually, Black people comprise 9% of those aged ≥65 years in the United States, suggesting a robust sampling in the current study.[33] Additionally, enrollment was evenly distributed, and intervention session adherence was similar by race, enhancing our ability to test for heterogeneity of intervention effect. We acknowledge there are inherent statistical power limitations for subgroup analyses assessing both the primary outcome and also secondary outcomes.[34] Accordingly, confirmation of results in the larger recently launched, National Institutes of Health–funded phase III clinical trial will be crucial for confirming the results (https://www.clinicaltrials.gov; Identifier NCT05525663).

CONCLUSIONS

In this diverse population of older patients hospitalized for ADHF, the intervention produced large improvements in physical function and HRQOL compared with attention control, irrespective of race. The clinical event data suggest that there may be a differential effect of the intervention by race on all-cause rehospitalization rates, highlighting the need for larger follow-up studies with robust recruitment across racial and ethnic groups.

ARTICLE INFORMATION

Received April 13, 2023; accepted September 19, 2023.

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Acknowledgments

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Sources of Funding

This study was supported in part by the following research grant awards from the National Institutes of Health: R01AG045551 and R01AG18915. It was also supported in part by the Kermit Glenn Phillips II Chair in Cardiovascular Medicine at Wake Forest School of Medicine (D.W.K.); National Institutes of Health Grant R01AG078153, U01AG076928, P30AG021332, and U01HL160272 (D.W.K.); P30AG028716 (A.M. Pastva), and U01HL125511 (R.J.M.); the Wake Forest Clinical and Translational Science Award, National Institutes of Health Grant UL1TR001420, and the Older Americans Independence Centers National Coordinating Center U24AG059624.

Disclosures

Dr Kitzman is a consultant for AstraZeneca, Pfizer, Corvia Medical, Bayer, Boehringer-Ingleheim, NovoNordisk, Rivus, and St. Luke's Medical Center in Kansas City, Kansas; received grant support from Novartis, AstraZeneca, Bayer, Pfizer, NovoNordisk, and St. Luke's Medical Center in Kansas City, Kansas; and owns stock in Gilead Sciences. Dr Mentz received research support and honoraria from Abbott, American Regent, Amgen, AstraZeneca, Bayer, Boehringer Ingelheim/Eli Lilly, Boston Scientific, Cytokinetics, Fast BioMedical, Gilead, Innolife, Medtronic, Merck, Novartis, Relypsa, Respicardia, Roche, Sanofi, Vifor, and Windtree Therapeutics. Dr Whellan received research support and is a consultant for Amgen, Cytokinetics,

Fibrogen, NovoNordisk, and ResMed. Dr Upadhya received support from Novartis and Corvia. Dr Reed received research support from Abbott Vascular, AstraZeneca, Novartis, Janssen Research and Development, and GSK, and honoraria from Sarepta, LabCorp, and COVIA Health Solutions. The remaining authors have no disclosures to report.

Supplemental Material

Data S1

REFERENCES

1. Kitzman DW, Whellan DJ, Duncan P, Pastva AM, Mentz RJ, Reeves GR, Nelson MB, Chen H, Upadhya B, Reed SD, et al. Physical rehabilitation for older patients hospitalized for heart failure. *N Engl J Med*. 2021;385:203–216. doi: 10.1056/NEJMoa2026141
2. Mentz RJ, Whellan DJ, Reeves GR, Pastva AM, Duncan P, Upadhya B, Nelson MB, Chen H, Reed SD, Rosenberg PB, et al. Rehabilitation intervention in older patients with acute heart failure with preserved versus reduced ejection fraction. *JACC Heart Fail*. 2021;9:747–757. doi: 10.1016/j.jchf.2021.05.007
3. Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Delling FN, et al. Heart disease and stroke statistics-2020 update: a report from the American Heart Association. *Circulation*. 2020;141:e139–e596. doi: 10.1161/CIR.0000000000000757
4. Bibbins-Domingo K, Pletcher MJ, Lin F, Vittinghoff E, Gardin JM, Arynchyn A, Lewis CE, Williams OD, Hulley SB. Racial differences in incident heart failure among young adults. *N Engl J Med*. 2009;360:1179–1190. doi: 10.1056/NEJMoa0807265
5. Loehr LR, Rosamond WD, Chang PP, Folsom AR, Chambless LE. Heart failure incidence and survival (from the atherosclerosis risk in communities study). *Am J Cardiol*. 2008;101:1016–1022. doi: 10.1016/j.amjcard.2007.11.061
6. Ye F, Nelson MB, Bertoni AG, Ditzenberger GL, Duncan P, Mentz RJ, Reeves G, Whellan D, Chen H, Pastva AM. Severity of functional impairments by race and sex in older patients hospitalized with acute decompensated heart failure. *J Am Geriatr Soc*. 2022;70:3447–3457. doi: 10.1111/jgs.18006
7. Churchwell K, Elkind MSV, Benjamin RM, Carson AP, Chang EK, Lawrence W, Mills A, Odom TM, Rodriguez CJ, Rodriguez F, et al. Call to Action: structural racism as a fundamental driver of health disparities: a presidential advisory from the American Heart Association. *Circulation*. 2020;142:e454–e468. doi: 10.1161/CIR.0000000000000936
8. Prince DZ, Sobolev M, Gao J, Taub CC. Racial disparities in cardiac rehabilitation initiation and the effect on survival. *PM R*. 2014;6:486–492. doi: 10.1016/j.pmrj.2013.11.016
9. Mathews L, Akhiwu O, Mukherjee M, Blumenthal RS, Matsushita K, Ndumele CE. Disparities in the use of cardiac rehabilitation in African Americans. *Curr Cardiovasc Risk Rep*. 2022;16:31–41. doi: 10.1007/s12170-022-00690-2
10. Zhang L, Sobolev M, Piña IL, Prince DZ, Taub CC. Predictors of cardiac rehabilitation initiation and adherence in a multiracial urban population. *J Cardiopulm Rehabil Prev*. 2017;37:30–38. doi: 10.1097/HCR.0000000000000226
11. Castellanos LR, Viramontes O, Bains NK, Zepeda IA. Disparities in cardiac rehabilitation among individuals from racial and ethnic groups and rural communities-a systematic review. *J Racial Ethn Health Disparities*. 2019;6:1–11. doi: 10.1007/s40615-018-0478-x
12. Reeves GR, Whellan DJ, Duncan P, O'Connor CM, Pastva AM, Eggebeen JD, Hewston LA, Morgan TM, Reed SD, Rejeski WJ, et al. Rehabilitation therapy in older acute heart failure patients (REHAB-HF) trial: design and rationale. *Am Heart J*. 2017;185:130–139. doi: 10.1016/j.ahj.2016.12.012
13. Reeves GR, Whellan DJ, O'Connor CM, Duncan P, Eggebeen JD, Morgan TM, Hewston LA, Pastva A, Patel MJ, Kitzman DW. A novel rehabilitation intervention for older patients with acute decompensated heart failure: the REHAB-HF pilot study. *JACC Heart Fail*. 2017;5:359–366. doi: 10.1016/j.jchf.2016.12.019
14. Pastva AM, Duncan PW, Reeves GR, Nelson MB, Whellan DJ, O'Connor CM, Eggebeen JD, Hewston LA, Taylor KM, Mentz RJ, et al. Strategies for supporting intervention fidelity in the rehabilitation therapy in older acute heart failure patients (REHAB-HF) trial. *Contemp Clin Trials*. 2018;64:118–127. doi: 10.1016/j.cct.2017.10.014
15. Warraich HJ, Kitzman DW, Whellan DJ, Duncan PW, Mentz RJ, Pastva AM, Nelson MB, Upadhya B, Reeves GR. Physical function, frailty, cognition, depression, and quality of life in hospitalized adults ≥60 years with acute decompensated heart failure with preserved versus reduced ejection fraction. *Circ Heart Fail*. 2018;11:e005254. doi: 10.1161/CIRCHEARTFAILURE.118.005254
16. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49:M85–M94. doi: 10.1093/geronj/49.2.m85
17. Cesari M, Landi F, Calvani R, Cherubini A, Di Bari M, Kortebein P, Del Signore S, Le Lain R, Vellas B, Pahor M, et al. Rationale for a preliminary operational definition of physical frailty and sarcopenia in the SPRINTT trial. *Aging Clin Exp Res*. 2017;29:81–88. doi: 10.1007/s40520-016-0716-1
18. Guyatt GH, Sullivan MJ, Thompson PJ, Fallen EL, Pugsley SO, Taylor DW, Berman LB. The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure. *Can Med Assoc J*. 1985;132:919–923.
19. Green CP, Porter CB, Bresnahan DR, Spertus JA. Development and evaluation of the Kansas City cardiomyopathy questionnaire: a new health status measure for heart failure. *J Am Coll Cardiol*. 2000;35:1245–1255. doi: 10.1016/s0735-1097(00)00531-3
20. Wancata J, Alexandrowicz R, Marquart B, Weiss M, Friedrich F. The criterion validity of the geriatric depression scale: a systematic review. *Acta Psychiatr Scand*. 2006;114:398–410. doi: 10.1111/j.1600-0447.2006.00888.x
21. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, Cummings JL, Chertkow H. The montreal cognitive assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. 2005;53:695–699. doi: 10.1111/j.1532-5415.2005.53221.x
22. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001;56:M146–M156. doi: 10.1093/gerona/56.3.m146
23. Carnethon MR, Pu J, Howard G, Albert MA, Anderson CAM, Bertoni AG, Mujahid MS, Palaniappan L, Taylor HA, Willis M, et al. Cardiovascular health in African Americans: a scientific statement from the American Heart Association. *Circulation*. 2017;136:e393–e423. doi: 10.1161/CIR.0000000000000534
24. Bortnick AE, Epps KC, Selzer F, Anwaruddin S, Marroquin OC, Srinivas V, Holper EM, Wilensky RL. Five-year follow-up of patients treated for coronary artery disease in the face of an increasing burden of comorbidity and disease complexity (from the NHLBI dynamic registry). *Am J Cardiol*. 2014;113:573–579. doi: 10.1016/j.amjcard.2013.10.039
25. Ahmad Y, Lansky AJ, Velazquez EJ. Current landscape and future directions of coronary revascularization in patients with heart failure. *JAMA Cardiol*. 2022;7:577–578. doi: 10.1001/jamacardio.2022.0659
26. Bell EJ, Lutsey PL, Windham BG, Folsom AR. Physical activity and cardiovascular disease in African Americans in atherosclerosis risk in communities. *Med Sci Sports Exerc*. 2013;45:901–907. doi: 10.1249/MSS.0b013e31827d87ec
27. Akwo EA, Kabagambe EK, Harrell FE, Blot WJ, Bachmann JM, Wang TJ, Gupta DK, Lipworth L. Neighborhood deprivation predicts heart failure risk in a low-income population of blacks and whites in the southeastern United States. *Circ Cardiovasc Qual Outcomes*. 2018;11:e004052. doi: 10.1161/CIRCOUTCOMES.117.004052
28. Kubicki DM, Xu M, Akwo EA, Dixon D, Muñoz D, Blot WJ, Wang TJ, Lipworth L, Gupta DK. Race and sex differences in modifiable risk factors and incident heart failure. *JACC Heart Fail*. 2020;8:122–130. doi: 10.1016/j.jchf.2019.11.001
29. Mentz RJ, Bittner V, Schulte PJ, Fleg JL, Piña IL, Keteyian SJ, Moe G, Nigam A, Swank AM, Onwuanyi AE, et al. Race, exercise training, and outcomes in chronic heart failure: findings from heart failure—a controlled trial investigating outcomes in exercise TraiNing (HF-ACTION). *Am Heart J*. 2013;166:488–495. doi: 10.1016/j.ahj.2013.06.002
30. Schultz WM, Kelli HM, Lisko JC, Varghese T, Shen J, Sandesara P, Quyyumi AA, Taylor HA, Gulati M, Harold JG, et al. Socioeconomic status and cardiovascular outcomes: challenges and interventions.

Circulation. 2018;137:2166–2178. doi: 10.1161/CIRCULATIONAHA.117.029652

31. Tkatch R, Artinian NT, Abrams J, Mahn JR, Franks MM, Keteyian SJ, Franklin B, Pienta A, Schwartz S. Social network and health outcomes among African American cardiac rehabilitation patients. *Heart Lung*. 2011;40:193–200. doi: 10.1016/j.hrtlng.2010.05.049
32. Nelson MB, Gilbert ON, Duncan PW, Kitzman DW, Reeves GR, Whellan DJ, Mentz RJ, Chen H, Hewston LA, Taylor KM, et al. Intervention adherence in REHAB-HF: predictors and relationship with physical function, quality of life, and clinical events. *J Am Heart Assoc*. 2022;11:e024246. doi: 10.1161/JAHA.121.024246
33. 2020 Profile of African Americans Age 65 and Older. United States Department of Health and Human Services: Administration for Community Living:1–5.
34. Brookes ST, Whitely E, Egger M, Smith GD, Mulheran PA, Peters TJ. Subgroup analyses in randomized trials: risks of subgroup-specific analyses; power and sample size for the interaction test. *J Clin Epidemiol*. 2004;57:229–236. doi: 10.1016/j.jclinepi.2003.08.009