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# The HEART Camp Exercise Intervention Improves Exercise Adherence, Physical Function, and Patient-Reported Outcomes in Adults With Preserved Ejection Fraction Heart Failure

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## ABSTRACT

**Background:** Despite exercise being one of few strategies to improve outcomes for individuals with heart failure with preserved ejection fraction (HFpEF), exercise clinical trials in HFpEF are plagued by poor interventional adherence. Over the last 2 decades, our research team has developed, tested, and refined Heart failure Exercise And Resistance Training (HEART) Camp, a multicomponent behavioral intervention to promote adherence to exercise in HF. We evaluated the effects of this intervention designed to promote adherence to exercise in HF focusing on subgroups of participants with HFpEF and heart failure with reduced ejection fraction (HFrEF).

**Methods and Results:** This randomized controlled trial included 204 adults with stable, chronic HF. Of those enrolled, 59 had HFpEF and 145 had HFrEF. We tested adherence to exercise (defined as ≥120 minutes of moderate-intensity [40%−80% of heart rate reserve] exercise per week validated with a heart rate monitor) at 6, 12, and 18 months. We also tested intervention effects on symptoms (Patient-Reported Outcomes Measurement Information System-29 and dyspnea-fatigue index), HF-related health status (Kansas City Cardiomyopathy Questionnaire), and physical function (6-minute walk test). Participants with HFpEF ($n = 59$) were a mean of 64.6 ± 9.3 years old, 54% male, and 46% non-White with a mean ejection fraction of 55 ± 6%. Participants with HFpEF in the HEART Camp intervention group had significantly greater adherence compared with enhanced usual care at both 12 (43% vs 14%, $phi = 0.32$, medium effect) and 18 months (56% vs 0%, $phi = 0.67$, large effect). HEART Camp significantly improved walking distance on the 6-minute walk test ($\eta^2 = 0.13$, large effect) and the Kansas City Cardiomyopathy Questionnaire overall ($\eta^2 = 0.09$, medium effect), clinical summary ($\eta^2 = 0.16$, large effect), and total symptom ($\eta^2 = 0.14$, large effect) scores. In the HFrEF subgroup, only patient-reported anxiety improved significantly in the intervention group.

**Conclusions:** A multicomponent, behavioral intervention is associated with improvements in long-term adherence to exercise, physical function, and patient-reported outcomes in adults with HFpEF and anxiety in HFrEF. Our results provide a strong rationale for a large HFpEF clinical trial to validate these findings and examine interventional mechanisms and delivery modes that may further promote adherence and improve clinical outcomes in this population.

**Clinical Trial Registration:** : URL: https://clinicaltrials.gov/. Unique identifier: NCT01658670 (*J Cardiac Fail 2021;00:1−11*)

**Key Words:** Heart failure, heart failure with preserved ejection fraction, heart failure with reduced ejection fraction, exercise, adherence.

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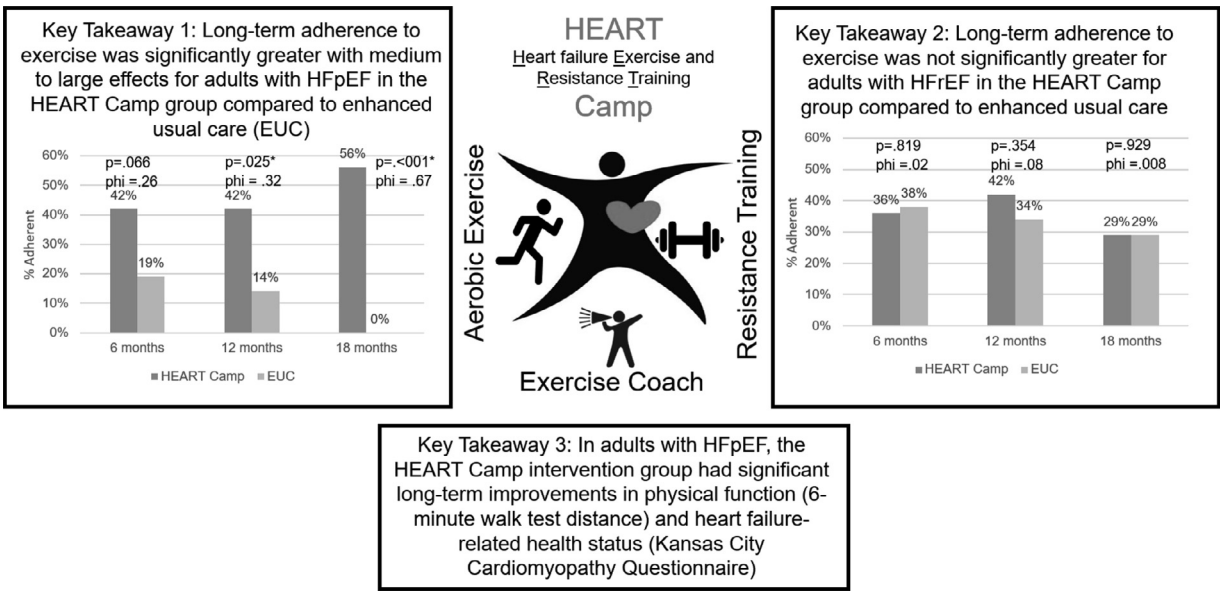
## Bullet Points

- Adults with heart failure with preserved ejection fraction (defined as an ejection fraction of ≥50%) responded favorably to the Heart Failure Exercise and Resistance Training (HEART) Camp.
- The HEART Camp intervention promotes adherence to exercise in adults with HFpEF compared with paid access to a fitness center alone.
- The HEART Camp intervention improved physical function, health status, and symptoms in adults with failure with preserved ejection fraction over time compared with paid access to a fitness center alone.

## Lay Summary

Heart Failure Exercise and Resistance Training (HEART) Camp is an exercise intervention that was previously successful at improving adherence to exercise in adults with heart failure. In this study, we divided the HEART Camp trial participants based on their ejection fraction into preserved ejection fraction (≥50%) and reduced ejection fraction (<50%) subgroups to see how the subgroups responded to the intervention compared with counterparts who were given only paid access to a fitness center. Adults with heart failure with preserved fraction significantly improved their exercise adherence with the HEART Camp intervention compared with a group receiving only access to a fitness center.

Visual Take Home Graphic




## Proposed Tweet

The multicomponent HEART Camp exercise coaching intervention promotes long-term adherence to exercise in adults with heart failure with preserved ejection fraction. #HeartFailure #HFpEF #ExerciseAdherence

Exercise is one of few successful strategies to improve outcomes in adults with heart failure with preserved ejection fraction (HFpEF). Yet, few adults with HF successfully meet the Heart Failure Society of America exercise guidelines that recommend 30 minutes of supervised moderate intensity exercise 5 days per week and long-term adherence to exercise interventions remains a challenge.[1,2] Cardiac rehabilitation has been the predominant model of exercise for adults with cardiovascular disease and heart failure; however, Medicare reimbursement is limited to those with an ejection fraction of less than 35% (heart failure with reduced ejection fraction [HFrEF]), which fails to account for half of the HF population, and cardiac rehabilitation is notoriously underused by those adults with HF who are eligible.[3,4]

Several exercise clinical trials have targeted adults with HFpEF and HFrEF.[5−14] The majority of these studies examined short-term effects (4−20 weeks) of exercise on physiologic changes such as peak oxygen uptake.[5−9,11−13] Most of these trials do report efficacy in improving physiologic measures with the exercise interventions, including aerobic, resistance, and/or high-intensity interval training, but few report adherence outcomes and no studies to date have resulted in significant improvements in mortality or hospitalizations. Further, few studies included patient-reported outcomes and, in those that did, only quality of life[6,10,12] and depression[13] were reported. Quality-of-life improvements were reported in some but not all studies and it was unclear if improvements were sustained.

Recent findings from the Rehabilitation Therapy in Older Acute Heart Failure Patients (REHAB-HF) trial, which recruited participants during a hospitalization for acute HF to attend 1-on-1 exercise training sessions that began during the hospital admission to 12 weeks, were promsing.[15] Adherence to exercise was reported as high as 76% during the intervention and 78% at the 3-month follow-up.[14] However, adherence during the 12-week intervention period was

measured by session attendance only and by patient self-report at the 3-month follow-up.[14]

Optimizing Exercise Training in Prevention and Treatment of Diastolic Heart Failure (Optimex-Clin)[10] is the only completed trial to date to recruit a HFpEF-only sample and examine long-term (12-month) exercise outcomes. Optimex-Clin randomized participants to high-intensity interval training, moderate intensity continuous training, and a control group that received only a guideline-based recommendation to exercise. Nonsignificant differences in the primary end point, namely, peak oxygen uptake at 3 months, were noted.[10] Adherence to Optimex-Clin at 12 months, measured as session attendance, was modest in both the moderate intensity continuous training and high-intensity interval training groups,[10] but proportionally higher when compared with adherence reported in 2 prior exercise clinical trials in HF: (a) the seminal, multicenter trial, Heart Failure − A Controlled Trial Investigating Outcomes of Exercise Training (HF-ACTION) (34% adherence)[16] and (b) prior work of this research team (42% adherence).[17] The dose-dependent response associated with exercise is difficult to achieve and maintain when participants are nonadherent to exercise.[18−20]

Our team developed and tested the multicomponent Heart failure Exercise and Resistance Training (HEART) Camp behavioral intervention to promote long-term adherence to exercise in adults with HF.[21] We defined adherence as achieving 120 or more minutes of moderate intensity exercise per week validated with a heart rate monitor. The HEART Camp intervention group achieved significantly better long-term adherence at 12 months (42%) and 18 months (35%) compared with enhanced usual care (28% and 19% adherence, respectively) in a mixed sample of adults with HFpEF and HFrEF.[22] The effects on adherence were moderated by the ejection fraction; those with higher ejection fractions at baseline achieved better long-term adherence. The HEART Camp also significantly improved physical function, quality of life, and depression.[23]

HF-ACTION ($n = 2331$) reported safety and efficacy of exercise in HF with reduced ejection fraction (HFrEF); however, participants with HFpEF were excluded.[16] A similar trial in HFpEF has not been reported. Our knowledge of successful interventional strategies to initiate and sustain exercise in HF, particularly in HFpEF, remains limited. Therefore, the purpose of this secondary data analysis is to evaluate the effects of the multicomponent, HEART Camp on adherence with exercise recommendations in the HFpEF and HFrEF subgroups as compared with enhanced usual care.

## Methods

### Design

The parent HEART Camp study was a 2-site, prospective, randomized 2-group repeated measures experimental design. Data were collected at 4 timepoints (baseline, 6, 12 and 18 months). Details of the study protocol and the results were published previously.[21−23] In brief, after enrollment and completion of a cardiopulmonary exercise test, all participants took part in a minimum of 6 scheduled, supervised exercise sessions in cardiac rehabilitation before randomization. During prerandomization exercise training sessions, participants learned moderate-intensity continuous training (40%−80% heart rate reserve)[22,24] and resistance training (10−15 repetitions to volitional fatigue).[25,26] The safety of all participants was ensured and plans for participant supervision were outlined clearly in the study protocol. Participants who completed these sessions were then randomized with stratification by study site and sex to 2 groups (HEART Camp or enhanced usual care). After randomization, all participants, including those randomized to enhanced usual care, received standard care for heart failure and were given paid access to a hospital-based exercise training facility where they could exercise independently for 18 months. This paid access was considered an enhancement beyond the standard care of individuals with HF and eliminated a potential financial barrier for participants. Participants randomized to the HEART Camp group received the HEART Camp intervention, which is described in greater detail elsewhere in this article.

### Setting and Sample for the Parent Study

The HEART Camp study team recruited 204 participants from 2 urban medical centers: Bryan Heart Institute in Lincoln, Nebraska, and Henry Ford Hospital in Detroit, Michigan. Inclusion and exclusion criteria are shown in Table 1. All participants provided written informed consent and the institutional review board at each site approved the study and provided oversight. The CONSORT diagram with screening and randomization details has been published previously.[22] Randomization was stratified by site and sex.

### Sample for the Subgroup Analyses

Recently, the Heart Failure Society of America, the Heart Failure Association of the European Society of Cardiology, and the Japanese Heart Failure Society published a universal definition of HF.[27] The new guideline suggests classification of HF on the basis of ejection fraction; individuals with an ejection fraction of 50% or more are classified as HFpEF.[27] We applied this classification to identify our subgroups for this post hoc analysis: HFpEF (EF of ≥50%, $n = 59$) and HFrEF (EF of <50%, $n = 145$).

### HEART Camp Intervention

The HEART Camp is a theory-driven, multicomponent intervention that focuses on participants' knowledge, attitudes, self-efficacy, self-management skills, and social support. The intervention took place over 3 phases, adoption (baseline to 6 months), transition (months 7−12) and maintenance (months 13−18). During the adoption and

**Table 1.** Inclusion and Exclusion Criteria for the HEART Camp Clinical Trial

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| 1 Diagnosis of systolic, diastolic, or combined chronic HF (stage C confirmed by echocardiography and clinical evaluation) | 1 Clinical evidence of decompensated HF |
| 2 19 years of age or greater | 2 Unstable angina pectoris |
| 3 Able to speak and read English | 3 Myocardial infarction, coronary artery bypass surgery, or biventricular pacemaker < 6 weeks prior |
| 4 Telephone access in home | 4 Orthopedic or neuromuscular disorders preventing participation in aerobic exercise and strength/resistance training |
| 5 Stable pharmacologic therapy per guidelines for past 30 days | 5 Participation in 3 times per week aerobic exercise in the past 8 weeks |
| | 6 Cardiopulmonary exercise test results that precluded safe exercise training |
| | 7 Plans to move more than 50 miles from the exercise site within the next year |
| | 8 Peak oxygen uptake in females >21 mL/kg/min and in males >24 mL/kg/min |
| | 9 Pregnancy planned or current |

HEART, Heart failure Exercise And Resistance Training; HF, heart failure.

transition phases, the intervention included individualized, weekly coaching with an exercise coach, where coaches and participants discussed goals, self-monitoring, relapse prevention, and self-management strategies. During the maintenance phase, face-to-face interaction between participants and coaches was stopped and participants were expected to self-manage their exercise. A detailed interventional protocol was published in 2014.[21]

### Data Collection and Measurement Tools

Baseline measures included demographic information (age, race, sex, and marital status) and clinical information (body mass index, left ventricular ejection fraction, and New York Heart Association functional class). Adherence to exercise (primary outcome) was calculated based on confirmed minutes of exercise per week. Participants achieving 120 or more minutes of moderate intensity exercise per week or more (80% of the Heart Failure Society of America recommended 150 minutes per week) were considered adherent. Minutes of exercise were collected using self-report diaries (collected weekly in the HEART Camp group and every 2 months in the enhanced usual care group) and validated using a heart rate monitor (Polar Electro Inco, Lake Success, NY). In designing our study, we elected to collect adherence data from participants in the enhanced usual care group every 2 months to avoid interventional effects from data collection. We preprogrammed the heart rate monitor with an individualized, target heart rate range that was determined based on results from each participant's cardiopulmonary exercise test and corresponded with 40%−80% of their heart rate reserve. Participants were instructed to wear the heart rate monitor during all exercise sessions and stay within the prescribed target heart rate range. We downloaded data into the Polar Pro Trainer, which provides details on date, time spent in exercise, average HR, and amount of exercise time within the target range. Any exercise minutes below the 40% heart rate reserve were not counted as minutes of exercise. Adherence levels for 6, 12, and 18 months were computed as the averages across the 4 weeks before each measurement time point. Participants achieving 120 or more minutes of moderate intensity exercise per week on average over this 4-week period were considered adherent at the given time point.

Secondary outcomes were tested at baseline, 6, 12, and 18 months and included objective physical function (6-Minute Walk Test [6MWT]) and patient-reported health status (Kansas City Cardiomyopathy Questionnaire [KCCQ]), anxiety, depression, role satisfaction, fatigue, pain interference, physical function, and sleep disturbance (Patient-Reported Outcomes Measurement Information System [PROMIS]-29). Each of these is metrics described in brief.

The 6MWT[28] is an objective measure of physical function performed to assess the exercise capacity of individuals with HF.[29] During this self-paced test, which has been standardized through guidelines provided by the American Thoracic Society,[28] participants walk on a flat, 100-foot walkway while research personnel measure the distance in meters walked in 6 minutes. In the HEART Camp study, participants were asked at baseline, 6, 12, and 18 months to complete two 6MWTs 7 days apart. The farthest distance walked between these 2 tests was recorded as the 6MWT measurement for that time point.

The KCCQ is a 23-item, HF-specific tool that measures 5 domains (physical limitation, symptoms, self-efficacy, quality of life, and social limitation) and generates 3 summary scores (overall summary score, clinical summary score, and total symptom score).[30] The KCCQ is commonly used in HF clinical trials and was recently recommended as an important

quality indicator by the 2020 American College of Cardiology/American Heart Association Task Force on Performance Measures.[31] Overall summary scores that change by 5 points or greater over time are considered clinically meaningful.[32] The KCCQ has been validated in adults with HFpEF.[33]

The PROMIS-29 uses 29 items to measure 7 domains, including anxiety, depression, role satisfaction, fatigue, pain interference, physical function, and sleep disturbance. PROMIS tools were developed by Cella et al[34] to capture patient-reported outcomes. These measures have been validated in the HF population.[35,36]

### Statistical Analyses

All statistical methods were applied across both the HFpEF and HFrEF subgroups. Descriptive statistics were calculated on all demographic and dependent variables. Data were compared between HEART Camp and enhanced usual care groups as well as HFpEF and HFrEF groups using $t$ tests and $\chi^2$ analyses as appropriate. To assess adherence between groups at 18 months (primary aim), a $\chi^2$ test was used to test group differences in the proportion of the sample that adhered to at least 80% of the 150 minutes per week recommendation. Tests were carried out at 6, 12, and 18 months, the primary data collection points in the study. A Fisher's exact test was completed for any time point with fewer than 5 participants in either group. The analysis included all participants according to the condition to which they were assigned and was based on all available data. (No data imputation was performed.) Missing data were assessed before analyses and our missing data rate is 18%.

Analysis of variance tests were completed to calculate effect sizes, reported as $\eta^2$, for secondary outcomes. To assess group differences in change over time on continuous outcomes, linear mixed models were performed for each dependent variable. Significant Time × Group interactions indicate significant differences in change over time between the HC and enhanced usual care groups. Variables were examined for normality by examining skew and kurtosis values. Although the PROMIS measures were distributed normally, the 6MWT and KCCQ variables were negatively skewed. Square transforms (or second power transforms) were effective in normalizing the distributions. SPSS version 25 was used for data management and descriptive statistics and SAS 9.4 was used for linear mixed models. Time was treated as a categorical variable because all intervals between time points and across participants were equal. Before assessing fixed effects, the most appropriate covariance structure was determined by performing models with various structures (eg, variance components, unstructured, Toeplitz, autoregressive) and comparing fit statistics. In the even that all fit statistics did not agree on the best error structure, preference was given to the more parsimonious structure. Additional models were performed to examine the effect of covariates (age, sex, body mass index, and race [White vs non-White]) on intervention effects in both subgroups. Statistical significance was set at the alpha 0.05 level.

## Results

The parent study enrolled 204 adults with stable chronic HF. Fifty-nine (29%) of these participants had an ejection fraction of 50% or greater (HFpEf subgroup) and 145 had an EF of less than 50% (HFrEF subgroup). The characteristics of the HFpEF and HFrEF subgroups are presented in Table 2. Participant characteristics were balanced between

**Table 2.** Participant Demographic and Clinical Variables

| | HFpEF Subgroup | | | HFrEF Subgroup | | |
|---|---|---|---|---|---|---|
| | HEART Camp ($n = 25$) | Enhanced Usual Care ($n = 34$) | $P$ Value | HEART Camp ($n = 77$) | Enhanced Usual Care ($n = 68$) | $P$ Value |
| Demographic variables | | | | | | |
| Age, mean (SD) | 63.3 (9.4) | 65.6 (9.3) | .367 | 58.6 (13.3) | 58.6 (10.1) | .987 |
| Female sex, $n$ (%) | 11 (44%) | 16 (47.1%) | .816 | 34 (44.2%) | 30 (44.1%) | .996 |
| Married, $n$ (%) | 18 (72%) | 20 (58.8%) | .296 | 34 (44.2%) | 41 (60.3%) | .052 |
| Non-Caucasian, $n$ (%) | 11 (44%) | 16 (47.1%) | .816 | 40 (51.9%) | 28 (41.2%) | .195 |
| Clinical variables | | | | | | |
| Ejection fraction, mean (SD) | 54.2 (5.7) | 55.7 (6.4) | .365 | 34.4 (9.3) | 32.9 (10) | .344 |
| NYHA class, $n$ (%) | | | | | | |
| I | 3 (12%) | 3 (8.8%) | .850 | 2 (12%) | 8 (8.8%) | .046 |
| II | 14 (56%) | 18 (52.9%) | | 40 (56%) | 41 (52.9%) | |
| III | 8 (32%) | 13 (38.2%) | | 34 (32%) | 18 (38.2%) | |
| IV | 0 | 0 | | 1 (1.3%) | 1 (1.5%) | |
| Beta blocker, $n$ (%) | 23 (92%) | 32 (94.1%) | .749 | 76 (98.7%) | 68 (100%) | .346 |
| ACE/ARB, $n$ (%) | 20 (80%) | 28 (82.4%) | .819 | 72 (93.5%) | 55 (80.9%) | .021 |
| BMI, mean (SD) | 35.6 (7.2) | 36.4 (8) | .708 | 34.7 (9.0) | 33.9 (7.6) | .532 |
| $pVO_2$ from cardiopulmonary exercise test | 15.6 (4.1) | 15 (4.5) | .662 | 14.6 (4.0) | 15.7 (3.6) | .099 |

ACE, angiotensin-converting enzyme Inhibitor; ARB, angiotensin-receptor blocker; BMI, body mass index; HEART, Heart failure Exercise And Resistance Training; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction; NYHA, New York Heart Association functional class; $pVO_2$, peak oxygen consumption; SD, standard deviation.

intervention and enhanced usual care groups in both the HFpEF and the HFrEF subgroups. Demographic and clinical variables were compared between the HFpEF and HFrEF subgroups. We found HFpEF participants were significantly older ($P = .001$) and less likely to be taking a beta blocker ($P = .025$) compared with HFrEF counterparts. There were no significant differences between the HFpEF and HFrEF subgroups on sex, race, marital status, body mass index, New York Heart Association functional class, or peak oxygen consumption.

In the HFpEF subgroup ($n = 59$), 54% identified as men. Ages ranged from 37 to 85 years (mean 64.6 ± 9.3 years) and the ejection fraction ranged from 50% to 76% in this subgroup with a mean of 55 ± 6%. Of the 27 non-Caucasian participants (45.8% of the sample), 25 were African American. In the HFrEF subgroup ($n = 145$), 81 (56%) identified as men and 64 (44%) as women. HFrEF participants were a mean age of 58.6 ± 11.9 years. Ejection fraction ranged from 12% to 49% in this subgroup with a mean of 33.7 ± 9.6%. Of the 68 non-Caucasian participants, 66 were African American. Adherence data are shown in Fig. 1a and 1b. Among patients with HFpEF in the HEART Camp group, adherence at both 12 months (42%) and 18 months (56%) was significantly greater compared with the enhanced usual care group (14% and 0%, respectively). At the 6-month time point, adherence was 42% in the HEART Camp group and 19% in the enhanced usual care group; this difference was not statistically significant. Among patients with HFrEF in the HEART Camp group, adherence at 6 months (36%), 12 months (42%), and 18 months (29%) was not significantly greater compared with the enhanced usual care group (38%, 34%, and 29%, respectively).

Participants with HFpEF in the HEART Camp group walked further during the 6MWT than enhanced usual care participants at all times points, including baseline, with the difference reaching significance at 18 months (Table 3). Distance in the HEART Camp group increased by 63.25 m compared with 13.16 m in the enhanced usual care group between baseline and 18 months, $F(2.7,73.1) = 4.14$, $P = .011$; $\eta^2 = 0.13$, large effect. In a hierarchical linear model, the Time × Group interaction for 6MWT distance was significant, as shown in Table 4, indicating that the groups differed significantly in change over time.

We identified significant differences between adults with HFpEF in HEART Camp and enhanced usual care on the KCCQ Overall Summary Score, $F(3,96) = 3.42$, $P = .02$; $\eta^2 = 0.09$, medium effect; the Clinical Summary Score, $F(3,95) = 6.17$, $P = .001$; $\eta^2 = 0.16$, large effect; and Total Symptom Score, $F(2.7,85.3) = 5.31$, $P = .003$; $\eta^2 = 0.14$, large effect. Between-group comparisons of overall change (Time × Group interactions) for the Dyspnea-Fatigue Inventory and domains of the PROMIS-29 were nonsignificant in hierarchical linear models. Results from all hierarchical linear models of data for the 6MWT, KCCQ, Dyspnea-Fatigue Inventory, and PROMIS-29 are reported in Table 4. We report means by group over time in Fig. 2a–c for those scores with significant Time × Group interactions.

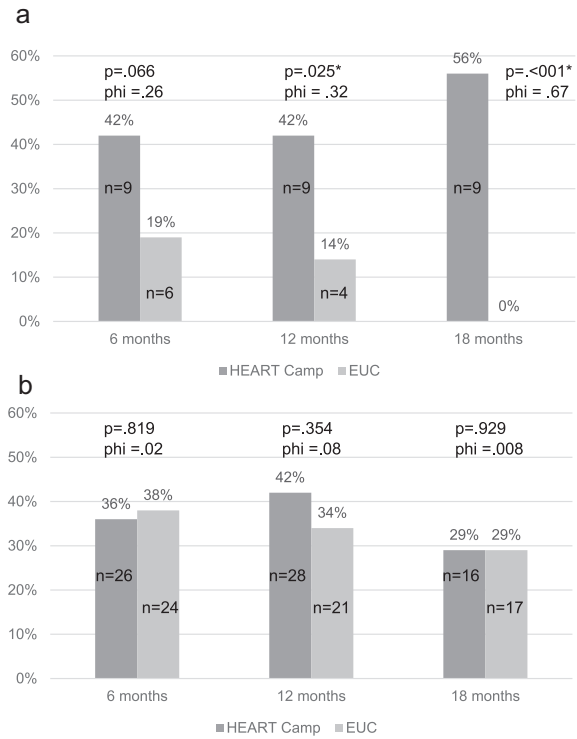



**Fig. 1.** (**A**) Longitudinal adherence to exercise in adults with heart failure with preserved ejection fraction (HFpEF) from the Heart failure Exercise And Resistance Training (HEART) Camp clinical trial using all available data. This figure demonstrates adherence for participants that completed data collection at each time point in the HFpEF subgroup. In the HEART Camp group, at 6 months, 9 of 21 (42%) were adherent to exercise, at 12 months, 9 of 21 (42%) were adherent, and at 18 months 9 of 16 (56%) were adherent to exercise. In the EUC group, at 6 months, 6 of 31 (19%) were adherent to exercise, at 12 months, 4 of 28 (14%) were adherent, and at 18 months 0 of 28 (0%) were adherent to exercise. *$\alpha = 0.05$. (**B**) Longitudinal adherence to exercise in adults with heart failure with reduced ejection fraction (HFrEF) from the HEART Camp clinical trial using all available data. This figure demonstrates adherence for participants that completed data collection at each time point in the HFrEF subgroup. In the HEART Camp group, at 6 months, 26 of 73(36%) were adherent to exercise, at 12 months, 28 of 67 (42%) were adherent, and at 18 months 16 of 55 (29%) were adherent to exercise. In the EUC group, at 6 months, 24 of 64 (38%) were adherent to exercise, at 12 months, 21 of 62 (34%) were adherent, and at 18 months 17 of 60 (29%) were adherent to exercise. Note: Adherence based on 120 minutes of moderate intensity or more of exercise per week. EUC, enhanced usual care (received paid access to an exercise facility).

In participants with HFpEF, the rate of attrition at the end of the 18-month study was 25.4%, with 44 participants completing heart rate validation and exercise diaries at 18 months. We had slightly greater attrition (32.2%) with study instruments; 40 of 59 participants completed all data points. The differences in attrition rates between groups was nonsignificant at all time points. Interestingly, when noncompleters were examined against completers on our measurement tools, the only difference we found in baseline measures was on the PROMIS-Sleep Disturbance. Completers had significantly lower scores (47.5) on the domain than noncompleters (54.8), $t(57) = 2.65$, $P = .01$,

**Table 3.** Six-Minute Walk Test Distance Over Time for Participants With HFpEF

| Group | Baseline | 6 months | 12 months | 18 months |
|---|---|---|---|---|
| HEART Camp, mean (SD) | 383.61 (117.63) | 411.21 (120.89) | 406.52 (140.94) | 446.86 (112.71) |
| Enhanced usual care, mean (SD) | 359.45 (101.46) | 370.98 (109.94) | 368.86 (118.11) | 372.61 (95.55) |
| *t* test *P* value | .402 | .241 | .346 | **.048** |

HEART, Heart failure Exercise And Resistance Training; HFpEF, heart failure with preserved ejection fraction; SD, standard deviation.
Bold font indicates statistical significance $\alpha$=.05.

**Table 4.** Hierarchical Linear Models of Physical Function, Heart Failure-related Health Status, and Patient-Reported Symptoms in Participants with HFpEF

| | | Num DF | Den DF | F | *P* Value |
|---|---|---|---|---|---|
| Six-minute walk test* | Time | 3 | 89 | 3.584 | .017 |
| | Group | 1 | 58 | 2.928 | .092 |
| | Time × Group | 3 | 89 | 5.718 | **.001** |
| KCCQ overall summary score | Time | 3 | 130 | 0.595 | .619 |
| | Group | 1 | 57 | 0.062 | .805 |
| | Time × Group | 3 | 130 | 3.981 | **.009** |
| KCCQ clinical summary score | Time | 3 | 131 | 0.742 | .529 |
| | Group | 1 | 57 | 0.014 | .906 |
| | Time × Group | 3 | 131 | 5.698 | **.001** |
| KCCQ total symptom score | Time | 3 | 131 | 0.647 | .586 |
| | Group | 1 | 57 | 0.006 | .939 |
| | Time × Group | 3 | 131 | 4.179 | **.007** |
| KCCQ quality of life | Time | 3 | 131 | 1.123 | .342 |
| | Group | 1 | 57 | 0.354 | .554 |
| | Time × Group | 3 | 131 | 2.518 | .061 |
| Dyspnea-fatigue inventory | Time | 3 | 131 | 2.063 | .108 |
| | Group | 1 | 57 | 0.419 | .520 |
| | Time × Group | 3 | 131 | 0.602 | .615 |
| PROMIS anxiety | Time | 3 | 131 | 0.639 | .591 |
| | Group | 1 | 55 | 2.044 | .158 |
| | Time × Group | 3 | 131 | 1.019 | .386 |
| PROMIS depression | Time | 3 | 130 | 1.371 | .255 |
| | Group | 1 | 57 | 1.266 | .265 |
| | Time × Group | 3 | 130 | 1.347 | .262 |
| PROMIS social satisfaction with roles | Time | 3 | 131 | 1.304 | .276 |
| | Group | 1 | 57 | 0.209 | .650 |
| | Time × Group | 3 | 131 | 1.877 | .137 |
| PROMIS fatigue | Time | 3 | 132 | 0.891 | .448 |
| | Group | 1 | 58 | 0.276 | .602 |
| | Time × Group | 3 | 132 | 2.267 | .084 |
| PROMIS Pain interference* | Time | 3 | 91 | 1.623 | .190 |
| | Group | 1 | 58 | 0.270 | .605 |
| | Time × Group | 3 | 91 | 0.264 | .851 |
| PROMIS physical function | Time | 3 | 130 | 2.133 | .099 |
| | Group | 1 | 57 | 0.538 | .466 |
| | Time × Group | 3 | 130 | 0.241 | .868 |
| PROMIS sleep disturbance* | Time | 3 | 97 | 1.433 | .238 |
| | Group | 1 | 59 | 0.296 | .588 |
| | Time × Group | 3 | 97 | 1.853 | .143 |

HFpEF, heart failure with preserved ejection fraction; KCCQ, Kansas City Cardiomyopathy Questionnaire; PROMIS, Patient-Reported Outcomes Measurement Information System.
Bold font indicates statistical significance $\alpha$=.05.
*An Autoregressive covariance structure; otherwise, a variance components structure.

indicating that noncompleters had greater sleep disturbance. A sensitivity analysis completed with all data from the parent HEART Camp study (previously reported) found no differences in findings as a result of excluding participants that did not complete the study.[22] In the current study, we completed a sensitivity analysis in the HFpEF subgroup, again with no changes in outcomes. This finding indicates that attrition did not bias outcomes or dilute significant findings.

All primary analyses were performed with the HFrEF subgroup. As mentioned elsewhere I this article, adherence did not differ significantly at any time point. Of the 13 outcome variables, only the PROMIS-Anxiety differed significantly over time (significant Time × Group interaction). PROMIS-Anxiety improved for the HEART Camp group, whereas anxiety increased in the enhanced usual care group. Otherwise, no differences were observed in the HFrEF subgroup.

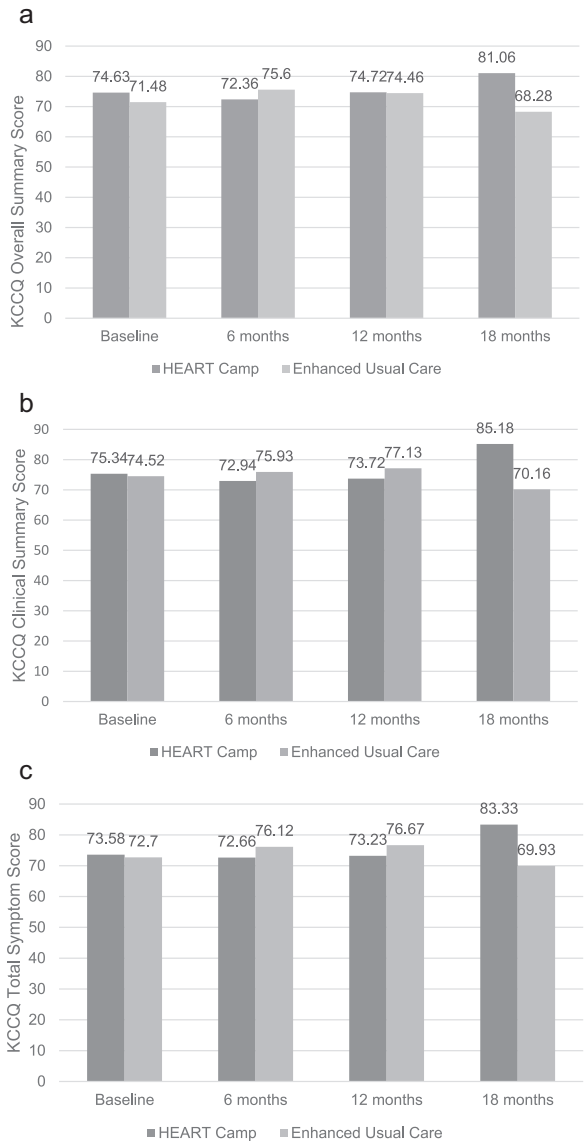



**Fig. 2.** (**A**) Kansas City Cardiomyopathy Questionnaire (KCCQ) Overall Summary Score. This figure shows the mean KCCQ overall summary scores in the heart failure with preserved ejection fraction (HFpEF) subgroup from baseline to 18 months. Analysis of variance (ANOVA) indicated a statistically significant change by group over time, $F(3,96) = 3.4$, $P = .02$. (**B**) KCCQ clinical summary score. This figure shows the mean KCCQ clinical summary scores in the HFpEF subgroup from baseline to 18 months. ANOVA indicated a statistically significant change by group over time, $F(3,95) = 6.2$, $P = .01$. (**C**) KCCQ Total Symptom Score. This figure shows the mean KCCQ total symptom scores in the HFpEF subgroup from baseline to 18 months. ANOVA indicated a statistically significant change by group over time $F(2.7,85.3) = 5.3$, $P = .003$.

To examine the effect of covariates in the models testing intervention effects in both subgroups, we added age, sex, body mass index, and race (White vs non-White) as covariates. Although these covariates were significant in some cases, there was no change in the significance of the Time × Group interaction in any of the models. Because the effectiveness of the intervention was not altered by the addition of the covariates, we reported the unadjusted models in the interest of model parsimony.

## Discussion

The purpose of this study was to evaluate the effects of the HEART Camp intervention on adherence to exercise, physical function, and patient-reported outcomes in the subgroups of adults with HFpEF and HFrEF as compared with enhanced usual care. In the HFpEF subgroup, adherence was significantly greater at 12 (42.9% vs 14.3%) and 18 (56% vs 0%) months in the HEART Camp intervention group compared with enhanced usual care. Physical function also improved significantly (based on 6MWT distances) over time in the HEART Camp group compared with enhanced usual care counterparts. Patient-reported outcomes, including heart failure-related health status (KCCQ Overall Summary Score), symptoms (KCCQ, Total Symptom Score), and clinical health status (KCCQ Clinical Summary Score) were also statistically and clinically significant when comparing HEART Camp to enhanced usual care. These findings are critically important given the limited successful treatment approaches in HFpEF. Our HFrEF subgroup did not achieve significant differences in adherence, physical function, or patient-reported outcomes aside from improvements in anxiety in the HEART Camp intervention group compared with enhanced usual care over time. This article is the first to report long-term adherence outcomes out to 18 months and the first to report sustained improvement in health status from 12 to 18 months in an exercise trial in adults with HFpEF.

Difficulties with initiation and continued adherence to exercise have plagued adults with HF, as well as HF clinicians. HF-ACTION, the largest study of exercise in HF to date, included only participants with reduced ejection fraction and reported adherence to the target of 120 minutes per week at 12 months to be 35%.[16,37] In our parent study of HEART Camp, we enrolled adults with stable chronic HF and adherence was similar at 42% in the intervention group at 12 months compared with 19% in the enhanced usual care group.[17]

Interventions such as financial incentives have been used to successfully encourage short-term (<6 months) participation in exercise or standard cardiac rehabilitation programs.[38] However, studies of long-term exercise programs or exercise adherence are limited with little data to inform effective intervention strategies. To date, Optimex-Clin is the only completed longer term (12-month) trial focused on adults with HFpEF. Investigators in the Optimex-Clin trial defined adherence as 70% or greater attendance at sessions. Using this definition, the trial's moderate continuous training (comparable with the HEART Camp moderate intensity aerobic training) achieved 60.4% adherence when considering the full 12-month study, which is similar to the adherence we achieved in our HFpEF subgroup of 56% at 18 months. When Optimex-Clin investigators considered the home-based portion of the intervention (months 4−12) alone, adherence was 58.5%.[10] In the recent REHAB-HF trial, adherence was high; however, adherence was measured by session attendance during the intervention period

and by patient self-report in the follow-up period.[14] Each of these surrogates for adherence is difficult to validate. Important to note is that the definition of adherence in HEART Camp was based on minutes of validated, moderate intensity exercise (defined as achieving 40%−80% of heart rate reserve). These differences in adherence definitions and measurements contribute to the difficulty of comparing adherence across studies. Establishing a standard definition of adherence is critical to enhancing intertrial comparisons in the future and should be made a priority by clinicians and exercise scientists, particularly in HFpEF where a large-scale clinical trial has yet to be undertaken. Without standardization, adherence will remain the perpetual Achille's heel of exercise programs in HF.[2]

Adults with HFpEF in our HEART Camp group responded more favorably than enhanced usual care peers in terms of physical function improvements as measured by 6MWT distances at 18 months. The findings were not only statistically significant ($P = .048$), but also associated with a positive and moderate change in clinical status. These results are consistent with short-term studies of exercise interventions with HFpEF.[5,6] Maldonado-Martin et al[5] reported significant improvements in 6MWT distances in an exercise training group vs attention-control in a 16-week exercise intervention trial. This intervention also improved ventilatory thresholds and peak oxygen consumption, but these outcomes were not significantly correlated with improvements in the 6MWT.[5] Caloric restriction in combination with exercise have been reported to work synergistically to improve 6MWT distance in HFpEF.[6] Physical function and health status continued to improve over time for adults with HFpEF in the HEART Camp intervention group. These improvements may have contributed to the observed increase in adherence seen between 12 and 18 months.

Interestingly, we did not find significant differences in adherence or most patient-reported outcomes when comparing HEART Camp with enhanced usual care in our HFrEF subgroup. This factor suggests that the findings reported in our primary outcome report were highly influenced by adherence in the HFpEF subgroup.[22] It is unclear whether these adherence findings were driven by differing pathophysiological and/or symptom profiles in HFpEF and HFrEF or disparate responses to exercise that led to improved adherence among those with HFpEF. Our findings are consistent with a subgroup analysis of REHAB-HF, in which older adults with HFpEF responded more favorably to the intervention than HFrEF counterparts.[39] In their analyses, adults with HFpEF responded favorably with large effect sizes on the short physical performance battery, the KCCQ, and 6MWT distance. Adherence was similar across HFpEF and HFrEF subgroups during the intervention and at follow-up. However, as noted elsewhere in this article, adherence was defined based on session attendance and patient self-report, which may not correspond with objectively measured minutes of moderate intensity exercise. Taken together, these findings support the potential usefulness of the HEART Camp intervention to promote adherence to exercise in adults with HFpEF and, ultimately, improve patient-reported outcomes in this population.

Several prior exercise interventions trials in HFpEF have tested intervention effects on quality of life and health status outcomes.[6,8,13,40] These trials have reported significant improvements in the physical domains of both the Short-form-36 and the Minnesota Living with Heart Failure Questionnaire after supervised aerobic and/or resistance training interventions.[40,41] In this subgroup analysis, participants in the intervention group reported a significantly greater change over time in their KCCQ overall summary, clinical summary, and total symptom scores compared with enhanced usual care. To date, 1 shorter term (20 weeks) study[6] and 1 longer term (12 months) study, Optimex-Clin[10] have used the KCCQ to test exercise effects on health status in HFpEF. Interestingly, Kitzman et al[6] reported that, in a trial of a caloric restriction intervention compared with and combined with exercise, caloric restriction alone improved KCCQ scores, but exercise did not. These findings may have resulted from the short-term intervention of only 20 weeks. Comparatively, our findings and the findings of Optimex-Clin over 12 months showed that, although initially the scores may be similar across intervention and control groups, over the long-term health status (as measured with the KCCQ) does seem to improve with exercise interventions.[10]

We tested interventional effects on symptoms using the PROMIS-29. We did not record significant changes between the groups in our HFpEF subgroup. This study is the first reported to examine change in specific symptoms in a trial of exercise in adults with HFpEF aside from depression. Prior studies have demonstrated that improvements in depression may be achieved with exercise interventions in adults with HFpEF.[13,40] Although we did not find significant changes here, we did note trends in improvement. Future fully powered studies are needed to see if these trends would reach significance. In our HFrEF subgroup, the HEART Camp intervention group reported significantly greater improvements in anxiety compared with enhanced usual care counterparts.

We would like to acknowledge the limitations of this study. This analysis is a retrospective, subgroup analysis from a parent study. Therefore, findings should not be generalized beyond this sample. We recruited from 2 sites in the United States, namely, Detroit, Michigan, and Lincoln, Nebraska. Despite the small number of sites, our sample was representative relative to race and biological sex across groups. Further, we used a consistent interventional protocol at both sites and closely monitored intervention fidelity as published previously.[42] We noted no differences in the intervention effects between sites and believe that our intervention has a high potential for translation. We acknowledge that, overall, our sample was younger and included more men than typically reported in the general HFpEF population. In the parent study, randomization occurred after a run-in period, which further limits the generalizability of our findings. The run-in period allowed for monitored exercise

sessions and equipment orientation before independent exercise to decrease the risk of participant injury or adverse events. Future studies may incorporate a stratified sampling approach to further diversify the sample.

## Conclusions

The findings of these subgroup analyses are highly encouraging, and additional research on alternative, cost-conscious delivery methods and a larger clinical trial of our multicomponent intervention to test long-term adherence in adults with HFpEF is warranted. Exercise remains one of few treatment strategies to successfully promote positive outcomes in adults with HFpEF. To further drive these improvements, interventions to support long-term adherence are critical.

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