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Acceptability, Feasibility and Preliminary Evaluation of a Novel, Personalised, Home-Based Physical Activity Intervention for Chronic Heart Failure (Active-at-Home-HF): a Pilot Study

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Abstract

Purpose: Less than 10% of heart failure patients in the UK participate in cardiac rehabilitation programmes. The present pilot study evaluated feasibility, acceptability and physiological effects of a novel, personalised, home-based physical activity intervention in chronic heart failure.

Methods: Twenty patients (68 ± 7 years old, 20% females) with stable chronic heart failure due to reduced left ventricular ejection fraction (31 ± 8 %) participated in a single-group, pilot study assessing the feasibility and acceptability of a 12-week personalised home-based physical activity intervention aiming to increase daily number of steps by 2000 from baseline (Active-at-Home-HF). Patients completed cardiopulmonary exercise testing with non-invasive gas exchange and haemodynamic measurements and quality of life questionnaire pre- and post-intervention. Patients were supported weekly via telephone and average weekly step count data collected using pedometers.

Results: Forty-three patients were screened and 20 recruited into the study. Seventeen patients (85%) completed the intervention, and 15 (75%) achieved the target step count. Average step count per day increased significantly from baseline to 3 weeks by 2546 (5108 ± 3064 to 7654 ± 3849, $P = 0.03$, $n = 17$) and was maintained until week 12 (9022 ± 3942). Following completion of the intervention, no adverse events were recorded and quality of life improved by 4 points (26 ± 18 vs. 22 ± 19). Peak exercise stroke volume increased by 19% (127 ± 34 vs. 151 ± 34 ml/beat, $P = 0.05$), while cardiac index increased by 12% (6.8 ± 1.5 vs. 7.6 ± 2.0 L/min/m^2, $P = 0.19$). Workload and oxygen consumption at anaerobic threshold also increased by 16% (49 ± 16 vs. 59 ± 14 watts, $P = 0.01$) and 10% (11.5 ± 2.9 vs. 12.8 ± 2.2 ml/kg/min, $P = 0.39$).

Conclusion: The Active-at-Home-HF intervention is feasible, acceptable and effective for increasing physical activity in CHF. It may lead to improvements in quality of life, exercise tolerance and haemodynamic function.

Trial Registration: www.clinicaltrials.gov NCT0367727. Retrospectively registered on 17 September 2018.

Keywords: Physical activity, Chronic heart failure, Home-based intervention, Behavioural change

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Key Points

- A personalized, home-based physical activity intervention is acceptable and feasible and could lead to improvement in exercise tolerance and quality of life in chronic heart failure patients.
- Increasing step count by at least 2000 steps per day may be a realistic goal for chronic heart failure patients.

Background

The benefits of cardiac rehabilitation in chronic heart failure (CHF) have been well documented [1]. Evidence-based clinical guidelines recommend that physical activity is integrated into cardiac rehabilitation as a cornerstone of clinical management of CHF [2]. Meta-analyses have demonstrated that increased physical activity can improve functional capacity and quality of life, can reduce symptom burden and likelihood of hospitalisation and can improve cardiac function [3, 4]. Consequently, current guidelines now emphasize physical activity as an important component of cardiac rehabilitation in addition to patient education, psychological support and drug therapy [2, 5, 6].

Despite numerous benefits, participation of heart failure patients in cardiac rehabilitation is low. In the United Kingdom (UK), less than 10% of patients with CHF participate in cardiac rehabilitation [7]. Potential explanations include exclusion of cardiac rehabilitation programmes from local commissioning agreements due to limited funds, lack of capacity for supervised programmes and inadequate social support for patients [8]. Other patient factors include unwillingness to participate in cardiac rehabilitation due to difficulties in attending hospitals, work or domestic commitments and reluctance to attend group-based classes [9].

The barriers highlighted above could be potentially overcome by promoting increased physical activity at home. Daily habitual physical activity (i.e. number of steps and active energy expenditure) is inversely related to patients' symptoms [10]. Walking is an independent predictor of outcomes in patients with advanced CHF [11]. Current physical activity recommendations for adults are 150 to 300 min per week of moderate-intensity activity, or 75 to 150 min per week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity while incorporating muscle-strengthening activities if tolerated [6]. For adults who are unable to meet these guidelines due to chronic conditions or disabilities, regular physical activity according to their ability is recommended [6]. As such, it may be challenging to identify a standardised daily physical activity routine appropriate for all heart failure patients' accounting for individual differences. Pedometer-based interventions have demonstrated that increasing steps per day by approximately 2000–2500 steps leads to improvements in blood pressure [12, 13] and insulin sensitivity [14]. Furthermore, a large cohort study involving 9306 participants reported a 10% risk reduction of cardiovascular events in individuals at high risk of developing type 2 diabetes for every 2000 steps per day increment in daily physical activity observed [15]. Considering these findings, we developed a novel, personalised, home-based (Active-at-Home-HF) physical activity intervention aiming to increase daily physical activity by 2000 steps in patients with CHF. The aim of the present pilot study was to assess feasibility, acceptability and preliminary efficacy of the Active-at-Home-HF intervention.

Methods

Study Design

A single-group, pilot study assessed the feasibility, acceptability and preliminary efficacy of a home-based physical activity intervention in adults with CHF with reduced left ventricular ejection fraction. Eligible participants attended the Clinical Research Facility of the Royal Victoria Infirmary, Newcastle upon Tyne, UK, for two separate visits (i.e. before and after the 12-week intervention). Participants were contacted via email, telephone or spoken to in person to discuss the study and given an opportunity to ask questions to ensure they understood the procedure.

Participants

Potentially eligible patients were identified by cardiologists via medical records from heart failure clinics at the Royal Victoria Infirmary and Freeman Hospital in Newcastle upon Tyne. These patients were subsequently screened by the same cardiologists using the study eligibility criteria. Once eligibility was confirmed, patients were recruited by a member of the research team (NO, SC) by telephone contact. The study included patients with a left ventricular ejection fraction ≤ 40%, diagnosed for at least 3 months, classified according to the New York Heart Association (NYHA) class II–III, clinically stable and receiving an optimal medical treatment. Patients were required to have no contraindications to physical activity and had to be capable of performing activities of daily living independently. Patients were excluded during screening or contact if they had uncontrolled cardiac arrhythmias, myocardial infarction, percutaneous coronary intervention and/or bypass graft surgery up to 3 months previously, severe obesity (i.e. body mass index > 40) and implantation with left ventricular assist device; were currently participating in a cardiac rehabilitation programme; if they already met physical activity recommendations [6]; or were unable to provide informed written consent.

Clinical Assessments

During baseline and 12-week follow-up visits, patients underwent clinical assessments including quality of life using the Minnesota Living with Heart Failure questionnaire, blood sampling for N-Terminal pro b-type Natriuretic Peptide (NTproBNP) and cardiopulmonary pulmonary exercise stress testing on a semi-recumbent cycle ergometer (Corival, Lode & Groningen, Netherlands) coupled with non-invasive haemodynamic monitoring (NICOM®, Cheetah Medical, Delaware, USA). A graded exercise test protocol was used for cardiopulmonary exercise testing. This involved maintaining a pedal frequency of 60–70 revolutions per minute with workload increasing at the rate of 10 W per minute. The test was terminated when maximal exertion was achieved, or when the patient was unable to maintain the required cycling cadence, or if the patient desired to stop. Physical activity (step count) was measured continuously using a pedometer (Omron Health care, Model no: HJ-321-E, Japan). Patients recorded daily step counts at the end of each day using a paper-based activity tracker, and results were communicated weekly to a member of the study team.

The Home-Based Physical Activity Programme (Active-at-Home-HF)

The Active-at-Home-HF intervention was designed for patients with CHF to encourage an increase in their overall daily physical activity levels by at least 2000 steps per day from baseline. This behavioural intervention was delivered by telephone to participants in the north-east of England who were patients at the Royal Victoria Infirmary or Freeman Hospital, Newcastle upon Tyne. The intervention team comprised of cardiologists, exercise physiologists and health psychologists. Team members (NCO and SC) involved in monitoring patients were experienced clinical exercise physiologists certified by the American College of Sports Medicine. They also received training delivered by a chartered health psychologist with expertise in health behaviour change (LA) who was also a member of the research team, on the delivery/use of evidence-based behaviour change techniques selected to target physical activity behaviour (e.g., physical activity goal setting, problem solving, self-monitoring) [16, 17]. The same health psychologist developed the brief behavioural intervention, intended for delivery by telephone using a proforma to prompt use of the specific behaviour change techniques. This proforma also served as a record for future discussions following completion during each intervention session delivered. The intervention differed from centre-based programmes in that it focussed on free-living physical activity, did not rely on exercise equipment, was delivered by weekly telephone sessions and focussed on providing participants with the knowledge and behavioural skills to increase and maintain physical activity levels despite the barriers they might face. Once patients enrolled in to the study, they were supported by weekly telephone calls lasting approximately 10 min in duration, designed to initiate, increase and maintain their activity levels. This was achieved through behavioural goal setting where the patient would set a physical activity goal with the guidance and support of a trained research team member. Barriers to reaching the goal were discussed followed by mutual identification of solutions to overcome those barriers. Patients were encouraged to consider times in the past where they had been more physically active as a means of increasing confidence and motivation. Self-monitoring was used to encourage maintenance of activity levels, and patients were prompted to involve family members and friends in their attempts to increase physical activity levels as a means of social support. At the end of each day, the goal was to achieve at least 2000 steps more than the average daily number of steps obtained at baseline as indicated on the pedometer. Physical activity levels were adjusted on an individual basis as conditioning took place, with the emphasis on volume of activity, i.e. duration and number of steps rather than intensity.

Outcomes

The primary outcomes of interest were acceptability and feasibility of the intervention. Secondary outcomes were changes in functional capacity assessed by peak exercise oxygen consumption and power output, quality of life, haemodynamic function and changes in NTproBNP. Feasibility was defined as willingness of patients to enrol on to the Active-at-Home-HF intervention and was confirmed by recruiting the targeted number of patients. The recruitment target deadline was set at 9 months after recruiting first patient. Acceptability was defined as willingness to engage with and adhere to the intervention and was reported as the percentage of patients who completed intervention. The intervention was considered acceptable if ≥ 80% of patients completed it. This included weekly engagement by telephone and completion of daily physical activity records. If engagement with each of these components was recorded, the intervention was considered acceptable.

Statistical Analysis

The primary aim of the present study was to assess acceptability and feasibility of the intervention. It is generally accepted that pilot feasibility studies do not require a formal power calculation [18]. However, it was important to assess whether the Active-at-Home-HF intervention, if acceptable and feasible, was capable of improving outcomes of interest to allow a judgement to be made as to whether the intervention is comparable to a centre-based intervention. It was therefore estimated that a sample size of 20 patients would provide sufficient power to detect a clinically acceptable change/increase in peak oxygen consumption of 3 ml/min/kg post-intervention, at the significance level of 5% ($\beta = 0.82$, $\alpha = 0.05$). The relationship between physical activity and physiological variables was assessed using Pearson's coefficient of correlation. Statistical significance was indicated if $P < 0.05$. All statistical analyses were carried out using SPSS version 24.0 (SPSS, Chicago, IL, USA).

Results

Acceptability and Feasibility

Out of 43 CHF patients contacted by telephone after initial screening, 20 patients met the study inclusion criteria and were willing to take part and were subsequently recruited. Recruitment took place between December 2015 and September 2016. Patients were excluded ($n = 23$) if they already met recommended physical activity guidelines [5] ($n = 4$), were too ill to participate (NYHA stage IV) or were recently hospitalised ($n = 8$). Patients were also excluded if they refused to participate for personal reasons ($n = 4$), time commitment ($n = 3$), 'feeling not be able to due to age' ($n = 1$) or being too nervous to participate in a physical activity intervention ($n = 3$). Recruited patients' demographic and clinical characteristics are presented in Table 1. No adverse events occurred as a result of participating in the intervention/study. Seventeen participants completed the 12-week physical activity intervention. However, two patients were unable to meet or sustain the required minimum target of 2000 steps above baseline due to severe arthritis. The intervention was considered acceptable and feasible as the required number of patients were recruited, and the majority of patients completed the intervention (completion rate 85%; $n = 17$) (see Fig. 1).

In situations where patients expressed concerns about their arrhythmias or ischaemia, they were further assessed by the team's consultant cardiologist and were reassured about safety of participation in the intervention before they took part in the study.

The target step count goal of 2000 steps from baseline was achieved at week three with average number of steps per day increasing significantly by 2546 (from 5108 ± 3064 to 7654 ± 3849 steps/day, $p = 0.03$), and was maintained until week 12 (8890 ± 3713 steps/day, Fig. 2). Two patients dropped out of the study for undisclosed reasons, and one participant discontinued due to implantable cardiac defibrillator malfunction.

Table 1 Mean and SD (±) of patients' demographic and clinical characteristics

Parameter	
Age (years)	68 ± 7
Men/women	18/2
Weight (kg)	84 ± 15
Height (cm)	1.72 ± 0.1
Aetiology of HF (IHD/DCM)	10/10
LVEF (%)	31 ± 8
Medication	
ACE inhibitors	15
β-blockers	20
ARBs	5
Diuretics	13
Anti-arrhythmic	3
NSAIDs/pain killers	6
Warfarin	5
ICD/pacemakers	13
Comorbidities	
COPD	1
Type 2 diabetes	5
Obesity	6
Hypertension	20
Depression	2
Arthritis	1

ACE angiotensin converting enzyme, *ARB* angiotensin receptor blockers, *LVEF* left ventricular ejection fraction, *NSAID* non-steroid anti-inflammatory drugs, *IHD*, ischaemic heart disease, *DCM* dilated cardiomyopathy, *COPD* chronic obstructive pulmonary disease, *ICD* implantable cardioverter defibrillator

Metabolic Changes

There was no statistically significant change in exercise tolerance with peak oxygen consumption and peak workload increasing post-intervention by 4.8% and 11% respectively. However, workload and oxygen consumption at submaximal exercise (i.e. anaerobic threshold) increased by 20% (49 ± 16 vs. 59 ± 14 watts, $P = 0.01$) and 11% (11.5 ± 2.9 vs. 12.8 ± 2.2 ml/kg/min, $P = 0.39$) post-intervention (Table 2).

Haemodynamic Changes

The completion of the intervention resulted in significant improvements in peak exercise stroke volume (126.5 ± 33.8 vs. 150.8 ± 33.5 ml/beat, $P = 0.05$) and stroke volume index (64.6 ± 14 vs. 75.2 ± 17 ml/beat/m^2, $P = 0.04$). There was also a 10–15% improvement in peak exercise cardiac output and cardiac index, although these were not statistically significant (Table 2).

Blood Biomarkers and Quality of Life

There were no statistically significant changes in metabolic biomarkers following completion of the

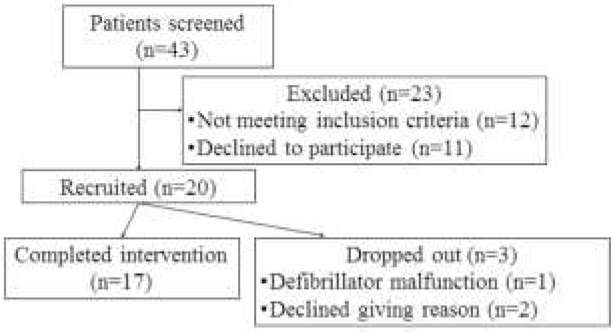

Fig. 1 Flow diagram showing patient screening and recruitment into Active-at-home HF intervention

intervention. There was a 4-point improvement in quality of life score (Table 3).

Daily number of steps correlated positively with peak oxygen consumption post-intervention ($r = 0.58$, $P = 0.01$), but not pre-intervention ($r = 0.39$, $P = 0.08$). The significant correlation observed post-intervention, although moderate, suggests that daily physical activity is positively associated with functional capacity (exercise tolerance) in active but not sedentary patients with chronic HF (Fig. 3). This suggests that increasing daily walking improves fitness levels in heart failure patients.

Discussion

The major findings of this study are that the Active-at-Home-HF intervention demonstrated to be both acceptable and feasible to patients with CHF and led to modest changes in exercise tolerance and haemodynamics. This was shown by the number of patients (85%) who engaged with and completed the intervention after enrolment. This figure is comparable to adherence rates (> 75%) reported from centre-based studies [19, 20]. Piotrowicz et al. [20], who compared a home-based tele-monitored cardiac rehabilitation to centre-based rehabilitation, reported 100% adherence in the home-based group. Seventy-five percent

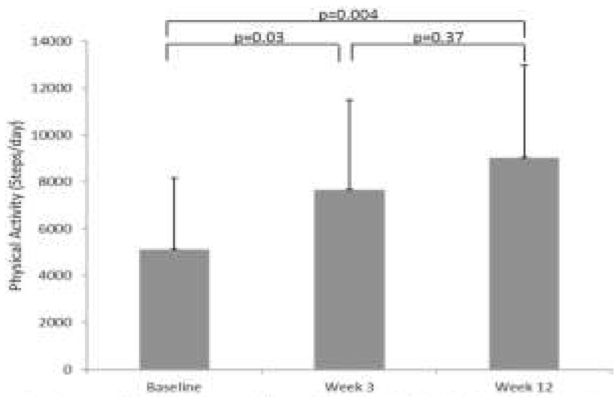

Fig. 2 Mean (+ SD) number of steps achieved at baseline and at the end of weeks 3 and 12 of physical activity intervention

Table 2 Cardio-metabolic changes (mean ± SD) following 12 weeks of Active-at-Home-HF intervention

	Pre-intervention	Post-intervention	*P* value	% change
Measurements at rest				
Oxygen consumption (ml/kg/min)	3.8 ± 1.0	4.1 ± 0.8	0.36	7.9
Respiratory exchange ratio	0.85 ± 0.1	0.85 ± 0.1	0.92	0
Heart rate (beats/min)	67 ± 7	70 ± 7	0.24	4.5
Stroke volume index (ml/beat)	48 ± 9	49 ± 8	0.75	2.0
Cardiac output (l/min)	6.1 ± 1	6.6 ± 1	0.14	8.2
Systolic blood pressure (mmHg)	118 ± 18	124 ± 18	0.41	4.0
Diastolic blood pressure (mmHg)	74 ± 8	76 ± 12	0.74	2.6
Mean arterial pressure (mmHg)	90 ± 9	92 ± 13	0.66	2.2
Measurements at peak exercise				
Oxygen consumption (ml/kg/min)	16.8 ± 3.8	17.6 ± 4.2	0.54	4.8
Respiratory exchange ratio	1.05 ± 0.1	1.07 ± 0.1	0.62	1.9
Heart rate (beats/min)	106 ± 19	107 ± 16	0.92	1.0
Stroke volume (ml/beat)	127 ± 34	151 ± 34	0.05	18.9
Stroke volume index (ml/beat/m^2)	64 ± 14	75 ± 17	0.04	17.2
Cardiac output (l/min)	13.4 ± 4	15.3 ± 4.9	0.19	14.2
Cardiac index (l/min/m^2)	6.8 ± 1.5	7.6 ± 2.0	0.19	11.7
Systolic blood pressure (mmHg)	155 ± 30	150 ± 30	0.62	3.2
Diastolic blood pressure (mmHg)	80 ± 8	79 ± 8	0.72	1.3
Mean arterial pressure (mmHg)	103 ± 13	102 ± 13	0.87	1.0
Peak exercise workload (watts)	82 ± 10	91 ± 19	0.21	11
Exercise workload at anaerobic threshold (watts)	49 ± 16	59 ± 14	0.01	20
Oxygen consumption at anaerobic threshold (ml/kg/min)	11.5 ± 2.9	12.8 ± 2.2	0.39	11.3
Rate of perceived exertion	16 ± 2.4	17 ± 2.3	0.22	6.3

of dropouts in the centre-based group of the above study were due to inadequate funds and availability of transport while 25% dropped out due to difficulty in matching the centre-based training with their daily activities. These findings are important because the intervention has shown to provide a viable and potentially low-cost (i.e. brief behavioural intervention delivered by telephone, no reliance on exercise equipment provision in clinical settings) alternative to centre-based programmes for patients not wanting to engage in group-based rehabilitation and is a solution to overcome other barriers including travel constraints.

Patients with heart failure often experience a decline in health-related quality of life. Following clinical presentation/

Table 3 Blood biomarkers and quality of life (mean ± SD) following 12 weeks of Active-at-Home-HF

	Pre-intervention	Post-intervention	*P* value	% change
Cholesterol (mmol/l)	4.0 ± 0.9	3.9 ± 0.9	0.59	2.5
Triglyceride (mmol/l)	1.5 ± 0.7	1.8 ± 0.9	0.45	20
HDL (mmol/l)	1.2 ± 0.3	1.1 ± 0.3	0.67	8.3
LDL (mmol/l)	2.1 ± 0.7	1.9 ± 0.7	0.46	9.5
HbA1c (mmol/mol)	49.2 ± 17.3	47.5 ± 12	0.77	3.5
FBG (mmol/l)	6.2 ± 2.9	7.0 ± 3.8	0.56	12.9
NT proBNP (pg/ml)	823 ± 1085	876 ± 1114	0.89	6.4
Renal function eGFR	65.4 ± 18.6	61.4 ± 17.4	0.61	6.1
QoL	26 ± 18	22 ± 23	0.50	15.4

HDL high-density lipoprotein, *LDL* low-density lipoprotein, *HBA1c* glycated haemoglobin, *FBG* fasting blood glucose, *NT proBNP* N-terminal brain natriuretic peptide, *QoL* quality of life, *eGFR* glomerular filtration rate

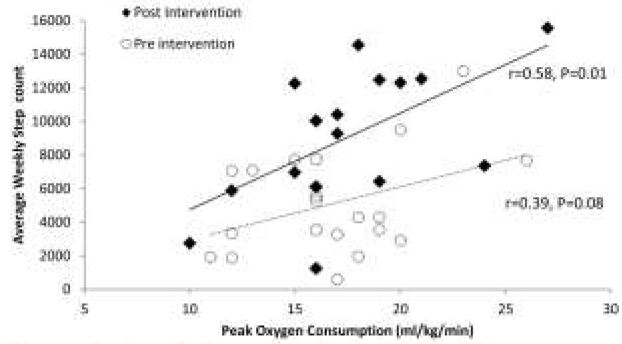

Fig. 3 Relationship between number of steps and peak oxygen consumption pre- and post-intervention

diagnosis, psychological distress can limit activity and lead to a decline in quality of life [21]. Exercise training has been reported to improve quality of life in CHF [22], and a reduction of 5 points or more in the Minnesota living with heart failure questionnaire is accepted as being clinically significant [23]. The present pilot feasibility study reported a 15% (4 point) reduction in quality of life score (i.e. an improvement in quality of life) which is deemed clinically insignificant and as thus contrast studies that have reported a significant improvement in quality of life following exercise intervention [24]. However, a 15% improvement is positive in a group of participants who reported a higher than average quality of life score at baseline (i.e. mean values of 26 points out of a possible score of 105 points in the questionnaire). Cowie et al. [25] also reported no significant change in quality of life in CHF patients following home-based or hospital-based intervention, even though there was a significant improvement in exercise capacity. They further suggested that in older CHF patients, maintaining quality of life rather than improving it might be a realistic aim for a physical activity or rehabilitation programme.

At anaerobic threshold, participants were able to tolerate significantly greater workload (17% increase). This finding is similar to previous studies that also reported a delay in reaching anaerobic threshold [26] and a significant increase in power output at anaerobic threshold [27].

Similarly, increased daily physical activity resulted in a 19% significant increase in peak stroke volume. Our results suggest positive adaptation to the intervention and the improvement of systemic oxygen delivery. Other studies have also reported significant improvements in an echocardiogram-generated stroke volume as a result of long-term (> 12 weeks) exercise training [28]. The capacity to increase physical activity depends on the ability of the heart to generate adequate cardiac output and the ability of skeletal muscles to utilise the oxygen delivered [29]. Therefore, this provides strong evidence for the assessment of cardiac heamodynamics in response to a physical activity intervention. These findings have been extended by other studies which demonstrated that aerobic training also improves diastolic filling, myocardial contractility and left ventricular ejection fraction in individuals with severe left ventricular systolic dysfunction [30, 31]. Based on the findings of the current study and evidence from the above-mentioned studies, it is reasonable to suggest that physical activity in CHF can improve cardiac contractility and stroke volume, potentially leading to reverse remodelling. The present study also found that increased physical activity as recorded from step counts following the Active-at-Home-HF intervention had a stronger correlation with peak oxygen consumption compared with lower step counts (sedentary behaviour) pre-intervention. Jehn et al., who reported a positive correlation between the times spent in light activity/exercise (≤ 3 METs) and improved peak oxygen consumption [11], had demonstrated this previously.

Although the use of steps per day has been criticised for not taking into account exercise intensity [32], a recent study by Tudor-Locke et al. [33] has shown that linear trends for steps per day were statistically significant for cardio-metabolic risk factors including blood pressure for men, weight, waist circumference, insulin, high-density lipoprotein, triglycerides and homeostasis model assessment-estimated insulin resistance. Even at step counts of around 70 steps per minute, which is below the recommended 100 steps per minute suggesting moderate intensity [32], clinically favourable values for many of the cardio-metabolic outcomes were observed. The present study provides further justification for the use of steps per day recommendations in national physical activity guidelines [34]. Furthermore, the present study results are of clinical importance for the management of CHF patients, particularly older adults as most patients have concomitant exercise-limiting comorbidities such as neuromuscular or orthopaedic problems making the traditional 10,000 step target [35] or steps per minute unrealistic and potentially harmful. As such, it may be appropriate to encourage such patients to exercise at a lower intensity than has been considered necessary to increase maximal exercise capacity.

Limitations

The following limitations should be considered in the present study. Firstly, it could be argued that sample size limits generalisability of findings. Of the 43 patients screened, only 20 were enrolled into the study meaning a recruitment rate of 46%. However, this was a pilot study with the primary aim of establishing acceptability and feasibility of the intervention. A further criticism could be that this study lacked a control group. However, the primary intention of this study was not to establish the effect of the intervention, instead, it was to assess feasibility and acceptability with a view to informing a larger-scale evaluation (i.e. controlled trial) should the intervention prove to be feasible and acceptable. Secondly, it could be argued that stroke volume was measured non-invasively which is not the gold standard. However, the reproducibility of stroke volume measurements using the NICOM has previously been reported [36]. Lastly, only two female patients were recruited into the study limiting generalisability of the study findings in terms of gender. The nature of this pilot study did not necessitate the use of digital technologies. However, digital technologies which offer additional evaluation of haemodynamic function such as heart rate and blood pressure will be useful in future studies to improve safety of patients while engaging in physical activity, and would likely increase feasibility. Further evaluation of the ACTIVE-at-HOME intervention, clinical and cost-effectiveness is warranted in an adequately powered randomised controlled trial

Conclusion

The present study demonstrates that the novel, home-based physical activity intervention (i.e. Active-at-Home-HF) is acceptable and feasible and can provide clinical and physiological benefits to people living with CHF. The intervention is associated with increased habitual physical activity level, functional capacity and haemodynamic response to exercise. Significant changes in response to the Active-at-Home-HF intervention were observed in submaximal exercise capacity and cardiac response to exercise. The Active-at-Home-HF intervention provides a viable alternative to centre-based programmes. This helps to overcome barriers including travel cost and reluctance to participate in group-based activity. A larger multicentre study is warranted to further substantiate preliminary findings from the present study.

Abbreviations

CHF: Chronic heart failure; COPD: Chronic obstructive pulmonary disease; HF: Heart failure; NTproBNP: n-Terminal pro b-type Natriuretic Peptide; NYHA: New York Heart Association; UK: United Kingdom

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Authors' Contributions

DGJ, GAM, NO, LA, KB, IO and LV designed the study. NCO, SC, SJC, LA and DGJ performed the study and collected the data. NCO and DGJ analysed the data and drafted the manuscript. GAM, KB, IO, LV and PB reviewed the manuscript. All authors read and approved the final manuscript.

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Availability of Data and Materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The Health Research Authority-North East Tyne and Wear South Research Ethics Committee approved the study protocol (REC reference: 13/NE/0180). Informed consent was obtained from all individual participants included in the study in accordance with the Declaration of Helsinki.

Consent for Publication

Not applicable

Competing Interests

The authors, Nduka C. Okwose, Leah Avery, Nicola O'Brien, Sophie Cassidy, Sarah J. Charman, Kristian Bailey, Lazar Velicki, Iacopo Olivotto, Paul Brennan, Guy A MacGowan, and Djordje G Jakovljevic, declare that they have no competing interests.

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HOME BASED EXERCISE TRAINING (HBET) DAPAT MENINGKATKAN KAPASITAS FUNGSIONAL PASIEN GAGAL JANTUNG

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ABSTRAK

Pendahuluan: Latihan fisik untuk meningkatkan kapasitas fungsional pada penderita gagal jantung masih belum mendapatkan perhatian khusus dari petugas kesehatan. Kapasitas fungsional yang menurun berdampak pada penurunan kemampuan pasien dalam melakukan aktivitas sehari-hari. **Tujuan penelitian** : menganalisis peningkatan kapasitas fungsional setelah diberikan *home based exercise training* pada pasien gagal jantung. **Metode:** desain penelitian *pra-eksperimen* yaitu *one group pretest-posttest design*. Teknik sampling yang digunakan adalah *purposive sampling*, didapatkan 10 responden. Peneliti menggunakan teknik *6MWT* untuk mengumpulkan data kapasitas fungsional. **Hasil :** analisa data dilakukan dengan menggunakan *uji paired t test.* Hasil analisa dapat diperoleh nilai p = 0,001 (α=0,05). Berdasarkan hasil penelitian menunjukkan kapasitas fungsional sebelum diberikan latihan adalah 245m dan setelah perlakuan sebesar 255 m. **Diskusi:** latihan fisik secara bertahap menyebabkan peningkatan daya pompa ventrikel sehingga terjadi peningkatan kapasitas fungsional. *HBET* dapat digunakan sebagai terapi modalitas keperawatan untuk meningkatkan kapasitas fungsional pasien gagal jantung setelah perawatan di rumah sakit.

Kata kunci : *Home Based Exercise Training (HBET)*, Peningkatan Kapasitas Fungsional, Gagal Jantung

HOME BASED EXERCISE TRAINING CAN INCREASE FUNCTIONAL CAPACITY OF PATIENT WITH HEART FAILURE IN RSUD BADUNG

ABSTRACT

Backround: *Physical exercise to increase functional capacity in people with heart failure has not received special attention from the health workers. Decreased functional capacity has an impact on reducing the patient's ability to carry out daily activities.* ***Purpose:*** *to analyze the increase in functional capacity after being given home based exercise training in patients with heart failure.* ***Method:*** *the research design used was pre-experimental, One Group Pretest-Post Test Design. The sampling technique used was purposive sampling, obtained 10 respondents. Functional capacity data collection is done by 6MWT.* ***Results:*** *data analysis was performed using paired t test. The results of the analysis can be obtained p = 0.001 (α = 0.05). The measurement results obtained a significant difference in functional capacity before (245 m) and (255 m) after treatment.* ***Discussion:*** *Physical exercise gradually causes an increase in the ventricular pumping power of the heart to increase functional capacity. HBET can be used as a nursing modality therapy to increase the functional capacity of heart failure patients after hospitalization*

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Keywords : Home Based Exercise Training (HBET), Increase Functional Capacity, Heart Failure.

PENDAHULUAN

Meningkatkanya angka prevalensi gagal jantung di dunia maupun di Indonesia menjadai masalah yang perlu diperhatikan. Sebesar 5,7 juta penduduk dunia menderita gagal jantung pada tahun 2013 dan mengalami peningkatan yang drastis menjadi 9,5 juta pada tahun 2014 dan mencapai angka 17,3 juta pada tahun 2015.[1] Sedangkan di Indonesia terjadi peningkatan dengan jumlah 182.344 penderita tahun 2013 menjadi 229.696 pada tahun 2014.[2]

Pasien gagal jantung sering mengalami gejala seperti sesak nafas, cepat lelah dan tidak bisa menjalani aktivitas fisik yang berat. Hal tersebut berdampak pada penurunan kemampuan untuk beraktifitas sehingga kapasitas fungsional tidak menurun.[3] Kapasitas fungsional adalah kemampuan individu dalam pemenuhan kebutuhan sktivitas sehari-hari. Upaya untuk meningkatkan kapasitas fungsional adalah dengan latihan fisik. Latihan fisik yang dimaksud berpedoman pada tipe latihan, intensitas atau seberapa sering latihan fisik tersebut dilakukan, lamanya latihan, dan frekuensi latihan. Jenis latihan yang aman dilakukan pada pasien gagal jantung stabil yaitu latihan aerobik selama 20-30 menit dimana latihan tersebut aman dilakukan tiga kali seminggu dengan intensitas latihan sebesar 40-60% dari denyut jantung maksimal.[4]

Latihan fisik penderita gagal jantung belum mendapatkan perhatian yang memadai seperti pada infark miokard dan penyakit jantung koroner. Berdasarkan beberapa penelitian yang pernah dilakukan bahwa latihan fisik bisa dilakukan dan sangat bermanfaat bagi pasien gagal jantung dalam keadaan stabil. Hal tersebut bertolak belakang dengan fenomena yang terjadi yaitu tingkat partisipasi dan pelaksanaannya masih rendah. Hal tersebut bisa disebabkan karena biaya dan kurangnya pemahaman masyarakat terkait manfaat latihan yang dilakukan.[4]

Home Based Exercise Training (HBET) merupakan jenis pelatihan untuk meningkatkan kapasitas fungsional pada pasien gagal jantung stabil. HBET adalah sebuah program pelatihan fisik yang dengan mudah bisa dilakukan oleh pasien setelah perawatan di rumah sakit. Penelitian Coats (1990) didapatkan setelah diberikan latihan fisik HBET konsumsi oksigen maksimal menjadi meningkat sebesar 17%, diikuti oleh peningkatan durasi latihan dan peningkatan kualitas hidup sebesar 18%. Adapun kelebihan latihan fisik HBET yaitu dapat dilakukan dimana saja tanpa harus mengeluarkan biaya tambahan.[5] Instrumen pengumpulan data dalam penelitian ini berupa *check list six minute walk test* (6MWT) untuk mengukur kapasitas fungsional. *Six minute walk test* mempunyai akurasi antara 83% sampai 91% untuk memprediksi VO_2max, jika hasil *6MWT* antara 450-490 meter. Terdapat korelasi yang kuat jika pasien mempunyai hasil *6MWT* <300 meter atau konsumsi oksigen maksimal rendah (<10mL/kg/min)[11].

METODE

Desain *pra eksperimen One Group Pretest-Posttest Design* merupakan desain yang digunakan dalam penelitian ini. Adapun populasinya adalah seluruh pasien gagal jantung di RSUD Badung. Pemilihan sampel dengan *non probability* yaitu *purposive sampling*[6]. Adapun sampel yang dipilih sesuai dengan kriteria inklusi yaitu pasien gagal jantung dengan klasifikasi kelas I dan II stabil yang ditandai dengan tidak ada nyeri dada, tidak sesak napas saat istirahat, denyut nadi istirahat 60-100 x/mnt dan reguler, tekanan darah sistolik 100-150 mmHg dan diastolik 60-90 mmHg. Peneliti menggunakan jumlah sampel minimal sebanyak 10 orang. Jumlah

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sampel untuk jenis penelitian eksperimen yang sederhana antara 10 sampai dengan 20 orang[6].

Pemberian intervensi *Home Based Exercise Training (HBET)* dilakukan pada bulan Mei – Juni sebanyak 12 kali dengan rincian tiga kali seminggu selama 30 menit untuk setiap kali latihan. Intensitas latihan yang diberikan yaitu 40-60% dari denyut nadi maksimal. Pemantauan latihan dilakukan oleh peneliti sendiri dibantu oleh enumerator yaitu perawat yang bekerja di Poliklinik Jantung menggunakan *SOP HBET*. Sebelum diberikan pelatihan HBET dilakukan pengukuran kapasitas fungsional di rumah pasien masing-masing. Setelah pemberian pelatihan selama 12 kali dilakukan pengukuran kembali sebagai nilai *post-test*.

HASIL PENELITIAN

Tabel 1.
Karakteristik Responden Berdasarkan Jenis Kelamin

Jenis kelamin	Frekuensi	Persentase
Laki-laki	4	40%
Perempuan	6	60%
Total	10	100%

Berdasarkan tabel 1 sebanyak 6 responden (60%) dengan jenis kelamin peempuan.

Tabel 2.
Distribusi frekuensi responden berdasarkan usia

Usia	Frekuensi	Persentase
<65 tahun	3	30%
>65 tahun	7	70%
Total	10	100%

Berdasarkan tabel diatas menunjukkan bahwa responden yang berusia >65 tahun sebanyak 7 responden (70%) sedangkan yang berusia <65 tahun sebanyak 3 orang (30%).

Tabel 3.
Distribusi frekuensi responden berdasarkan IMT

IMT	Frekuensi	Persentase
Obesitas	6	60%
Normal	4	40%
Total	10	100%

Hasil penelitian menunjukkan responden yang obesitas sebanyak 6 responden (60%) dan yang memiliki IMT normal sebanyak 4 orang (40%).

Tabel 4.
Kapasitas fungsional sebelum diberikan HBET

Variabel	Mean	SD	Min-mak
Kapasitas fungsional	279,72	22,32	245-309

Berdasarkan tabel diatas menunjukkan bahwa rata-rata kapasitas fungsional sebelum diberikan HBET adalah 279,72 meter (SD=22,32). Dapat disimpulkan bahwa nilai minimal kapasitas fungsional sebesar 245 meter dan nilai maksimal kapasitas fungsional sebesar 309 meter.

Tabel 5.
Kapasitas fungsional setelah diberikan HBET

Variabel	Mean	SD	Min-mak
Kapasitas fungsional	292,86	21,82	255-324

Berdasarkan tabel diatas menunjukkan bahwa rata-rata kapasitas fungsional setelah diberikan HBET adalah adalah 292,86 meter (SD=21,82). Nilai minimal kapasitas fungsional sebesar 255 meter dan nilai maksimal kapasitas fungsional sebesar 324 meter.

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Tabel 6.
Analisis perbedaan kapasitas fungsional sebelum dan sesudah HBET

Variabel		Mean	SD	p	n
Kapasitas fungsional	Pre- Post	279,72 292,86	22,32 21,82	0,0 01*	10

Hasil analisis uji statistik *paired t-test* dengan bantuan media komputer pada setiap variabel sebelum dan setelah diberikan HBET diperoleh tingkat kemaknaan α = 0,05 dimana nilai p yang diperoleh sebesar 0,001 sehingga kesimpulan penelitiannya H_0 ditolak dan H_1 diterima. Hal ini menunjukkan adanya pengaruh HBET terhadap kapasitas fungsional pasien gagal jantung.

PEMBAHASAN

Home Based Exercise Training **(HBET) dapat meningkatkan kapasitas fungsional pasien gagal jantung.**

Rata-rata kapasitas fungsional responden mengalami peningkatan 13,14 meter bila dibandingkan dengan pengukuran sebelum melakukan HBET. Hal ini berarti responden mengalami peningkatan kemampuan fungsional bila dibandingkan dengan pengukuran sebelumnya. Kondisi ini terjadi karena membaiknya fungsi pompa otot jantung karena managemen gagal jantung yang adekuat dan latihan fisik dengan HBET yang dilakukan secara teratur. Kombinasi antara terapi farmakologis, edukasi perubahan gaya hidup dan latihan fisik di rumah dengan HBET ini efektif untuk mempertahankan bahkan dapat meningkatkan kemampuan pompa ventrikel kiri. Hasil *paired t test* p *value* = 0,001 (<0,05) yang berarti terdapat perbedaan yang signifikan kapasitas fungsional sebelum dengan sesudah mendapatkan HBET selama 4 minggu.

McKelvie (2008) menyatakan peningkatan kualitas hidup dapat dicapai dengan melakukan latihan fisik secara rutin dan berkelanjutan. Kesembuhan pasien dapat dicapai dengan rutin melakukan latihan fisik. Manfaat yang didapatkan setelah melakukan sebuah pelatihan fisik adalah dapat meningkatkan toleransi latihan serta mempercepat proses kesembuhan bagi pasien. Peningkatan kapasitas fungsional dapat tercaai dengan melakukan *home based exercise training*. Pelatihan tersebut juga bermanfaat dalam menstabilkan berat badan, meningkatkan kapasitas oksidasi otot skeletal, memperbaiki kontrol syaraf otonom dan pembuluh darah.[8]

Latihan fisik dapat meningkatkan kapasitas fungsional yang berdampak pada perubahan fisiologis, psikologis dan muskuloskeletal. Sebuah pelatihan fisik yang dilakukan oleh penderita gagal jantung stabil dapat meningkatkan adaptasi fisiologis dari otot-otot yang dilatih, menstimulasi pengeluaran enzim aerobic serta *nitrit oxide*. Hal tersebut mengakibatkan penurunan tahanan pembuluh darah perifer serta memperbaiki volume darah yang dipompa oleh jantung. Hal tersebut bisa didapatkan melalui pelatihan HBET .[9]

Saat melakukan HBET, kebutuhan metabolik jaringan tubuh meningkat. Pada saat yang sama kebutuhan oksigen dan nutrisi untuk jaringan juga mengalami peningkatan dan di sisi lain banyak karbondioksida, toksin, dan produk lain yang tidak diperlukan dibuang. Pada orang sehat kondisi ini dikompensasi dengan peningkatan *cardiac output* bisa sampai 6 kali lipat dalam kondisi istirahat. Latihan fisik ini mencapai puncaknya pada kondisi *maximal oxigen uptake* (VC_2max). Pada saat VC_2max mencapai 80-90%, maka karbondioksida akan dibentuk secara berlebihan sehingga terjadi metabolisme otot anaerob dan peningkatan produksi asam laktat yang menghasilkan kelelahan berlebih. Latihan HBET yang dilakukan pada pasien gagal jantung stabil secara bertahap dapat meningkatkan kemampuan ventrikel jantung untuk

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memenuhi kebutuhan nutrisi dan oksigen jaringan sehingga terjadi peningkatan kapasitas fungsional.[10]

Peningkatan kapasitas fungsional setelah diberikan pelatihan *home based exercise training* (HBET) pada pasien gagal jantung dipengaruhi oleh frekuensi, intensitas, durasi dan mode latihan fisik. Selain itu setiap responden memiliki kemampuan untuk meningkatkan perawatan diri secara mandiri. Dukungan keluarga dan teman dekat sangat diperlukan untuk membangun kepercayaan diri yang positif dan meningkatkan kemampuan *self care* pasien. Adapun keterbatasan dalam penelitian ini adalah peneliti tidak memisahkan klasifikasi gagal jantung kelas I dan II sehingga tidak bisa dibedakan yang mengalami perubahan kapasitas fungsional secara signifikan, peneliti tidak dapat mengontrol aktivitas fisik lain yang dilakukan responden yang dapat mempengaruhi efek terapi HBET serta pengkategorian IMT responden yang tidak homogen.

SIMPULAN

1. Nilai rata-rata kapasitas fungsional sebelum diberikan terapi *home based exercise training* (HBET) adalah 279,72 meter (SD=22,32).
2. Nilai rata-rata kapasitas fungsional setelah diberikan terapi *home based exercise training* (HBET) adalah 292,86 meter (SD=21,82).
3. Kapasitas fungsional mengalami peningkatan rata-rata 13,14 meter bila dibandingkan dengan pengukuran sebelum diberikan terapi HBET. Hasil uji statistik dengan *Paired T-test* diperoleh nilai *p-value* sebesar 0,001 sehingga *p-value* < α (0,05) maka pemberian terapi *home based exercise training* (HBET) mampu meningkatkan kapasitas fungsional pada pasien gagal jantung.

SARAN

Berdasarkan hasil penelitian diatas dapat digunakan sebagai salah satu dasar pengembangan *evidence based nursing* untuk mendapatkan intervensi mandiri keperawatan yang terbukti efektif dan aman dilakukan pada pasien gagal jantung. HBET dapat juga dimasukkan dalam program rehabilitasi pasien gagal jantung di rumah sakit. Keluarga dan pasien diharapkan dapat menjadikan penelitian ini sebagai pedoman dan dapat memotivasi pasien untuk patuh terhadap terapi yang dijalankan baik di rumah sakit maupun dirumah.

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DAMPAK *HOME BASED EXERCISE TRAINING* TERHADAP KAPASITAS FUNGSIONAL PASIEN GAGAL JANTUNG

The Impact Of The Home Based Exercise Training To Functional Capacity Of Heart Failure Patient

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ABSTRAK

Kanker serviks adalah kanker yang menyerang uterus yaitu bagian serviks uterus atau leher rahim, merupakan Penurunan toleransi latihan dan sesak nafas merupakan manifestasi klinis utama gagal jantung. Kondisi ini menyebabkan pasien tidak dapat melakukan aktivitas sehari-hari yang berakibat pada penurunan kapasitas fungsional. Tujuan dari penelitian ini adalah mengidentifikasi dampak HBET terhadap kapasitas fungsional pasien gagal jantung. Desain penelitian ini adalah *quasi experiment, pre-post with control group*. Teknik sampling yang digunakan *purposive sampling*, didapatkan 23 responden yang terbagi menjadi 11 responden kelompok kontrol dan 12 responden kelompok intervensi. Pengumpulan data kapasitas fungsional dilakukan dengan *6MWT*. Hasil pengukuran didapatkan perbedaan yang signifikan kapasitas fungsional sebelum dan setelah perlakuan pada kedua kelompok. Hasil analisis kapasitas fungsional setelah perlakuan antara kelompok kontrol dan intervensi tidak didapatkan perbedaan yang signifikan, walaupun kelompok intervensi mempunyai mean kapasitas fungsional. Berdasarkan hasil penelitian tersebut, *HBET* dapat digunakan sebagai modalitas keperawatan bagi pasien gagal jantung. *HBET* hendaknya dijadikan bagian integral dari management gagal jantung setelah keluar dari rumah sakit.

Kata Kunci : *Home based exercise training*, kapasitas fungsional, dan gagal jantung

ABSTRACT

A reduced exercise tolerance and shortness of breathing are the main clinical manifestations in patient with heart failure. These conditions cause patient's inability to do their daily activities and lead to reduce functional capacity. The aim of this study was to identify the impact of the home based exercise training to functional capacity of heart failure patient. It used quasy experimental study design pre-post with control group, recruited 23 respondents with purposive sampling technique. They were divided into two groups, 11 respondents as control group and 12 respondents as experimental group. Functional capacity was obtain through observation of six minute walk test. The result showed that there was a significant difference of functional capacity before and after intervention in both groups. Statistically, the result of functional capacity data analysis after intervention showed that there wasn't significant difference in both groups, although the experimental group has a higher mean data of functional capacity. Based on this study, HBET could be used as nursing modality for patient with heart failure. HBET should be integrated with heart failure management after discharging from hospital.

***Keyword :** Home based exercise training, functional capacity, and heart failure*

LATAR BELAKANG

Gagal jantung adalah ketidakmampuan jantung untuk memompa darah secara adekuat untuk memenuhi kebutuhan metabolisme tubuh akan nutrisi dan oksigen (Leslie, 2004; Polikandrioti, 2008). Insiden gagal jantung mengalami peningkatan secara konsisten, walaupun terjadi kemajuan teknologi dalam diagnosis dan penatalaksanaan gagal jantung. Di Amerika Serikat 5,7 juta orang menderita gagal jantung, 670.000 kasus baru didiagnosa setiap tahun. Penyakit ini sering menyebabkan ketidakberdayaan dan mempunyai prognosis yang buruk (Tsao and Gibson, 2004).

Manifestasi klinis gagal jantung yang sering terjadi adalah penurunan toleransi latihan dan sesak nafas (Black and Hawk, 2009; Scub and Caple, 2010). Kedua kondisi ini menyebabkan ketidakmampuan melakukan aktivitas sehari-hari, mengganggu atau membatasi pekerjaan atau aktivitas yang disukai. Akibatnya pasien kehilangan kemampuan fungsional. Pada pasien gagal jantung, kapasitas fungsional sangat berkaitan erat dengan kualitas hidup pasien. Peningkatan kapasitas fungsional memberikan kemampuan pada pasien untuk melakukan aktivitas secara mandiri dan bermakna secara sosial.

Kapasitas fungsional dapat ditingkatkan, salah satunya dengan melakukan latihan fisik. Latihan ini meliputi: tipe, intensitas, durasi, dan frekuensi tertentu sesuai dengan kondisi pasien. Latihan fisik dengan aerobik selama 20-30 menit, 3 kali per minggu dengan intensitas 40-60% dari *heart rate reserve*, aman dilakukan pada pasien gagal jantung stabil (Myers, 2008; ESC dalam Nicholson, 2007). Latihan fisik pada pasien gagal jantung dapat meminimalkan gejala, meningkatkan toleransi latihan, kualitas hidup, dan mungkin dapat juga memberikan efek yang memuaskan bagi kesembuhan pasien (McKelvie et al, 2008). Hasil penelitian menyatakan latihan fisik aman dan bermanfaat bagi pasien gagal jantung, tetapi tingkat partisipasi dan pelaksanaannya masih rendah. Tujuh puluh sampai delapan puluh prosen pasien penyakit arteri koroner tidak berpartisipasi dalam program rehabilitasi jantung (Reid et al, 2006). Kondisi ini dipengaruhi oleh beberapa hal diataranya: biaya, kemampuan akses layanan oleh masyarakat, dan format latihan yang ditawarkan (Corvera-Tindel et al, 2004).

Home-based exercise training (HBET) dapat menjadi salah satu pilihan latihan fisik dan alternatif solusi rendahnya partisipasi pasien mengikuti latihan fisik. HBET merupakan latihan fisik terprogram yang dapat dijalankan oleh pasien secara mandiri di rumah. Di Indonesia latihan fisik dilakukan secara terpusat di rumah sakit. Data resmi tentang cakupan dan partisipasi program ini pada pasien gagal jantung di Indonesia belum didapatkan. Sampai saat ini penulis belum mendapatkan laporan adanya program latihan fisik dan pedoman latihan fisik yang terpusat di rumah sakit maupun HBET bagi pasien gagal jantung di rumah sakit tersebut. Perawat juga belum memberikan pendidikan kesehatan yang memadai karena tidak tersedianya protokol latihan fisik di rumah sakit tersebut. Tujuan dari penelitian ini adalah mengidentifikasi dampak *home based exercise training* (HBET) terhadap kapasitas fungsional dan kualitas hidup pasien gagal jantung di RS Ngudi Waluyo Wlingi.

METODE

Penelitian ini menggunakan desain *quasi eksperimen*, dengan menggunakan *pre-post with control group*. Populasi dalam penelitian ini adalah semua pasien gagal jantung stabil yang diindikasikan segera pulang atau rawat jalan di Ruang Dahlia I dan Dahlia II RSUD Ngudi Waluyo Wlingi. Teknik sampling yang digunakan adalah *teknik non probability sampling* yaitu *consecutive sampling*. Intervensi yang dilakukan berupa *home based exercise training* berupa jalan kaki selama 30 menit, 3 kali dalam seminggu selama 4 minggu dengan intensitas 40-60% *heart rate reserve*. Pengumpulan data Kapasitas fungsional dilakukan dengan Six Minute Walk Test (6MWT).

HASIL DAN PEMBAHASAN

Responden yang berpartisipasi dalam penelitian sebanyak 28 orang yang dibagi menjadi kelompok kontrol (n=24) dan kelompok intervensi (n=24). Responden dilakukan tes awal dengan 6MWT, setelah mendapatkan perlakuan selama 4 minggu dilakukan pengukuran ulang dengan alat ukur

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yang sama. Responden kelompok kontrol 1 orang meninggal dunia dan 2 orang drop uot karena tidak mengkonsumsi obat secara teratur sehingga tekanan darahnya naik. Responden kelompok intervensi 2 orang drop out karena melakukan HBET kurang dari ketentuan.

Kedua kelompok responden dalam penelitian (kelompok kontrol n= 11orang; kelompok intervensi n= 12 orang) mempunyai karakteristik yang setara (tabel 1). Sebelum perlakukan rerata kapasitas fungsional dengan 6MWT kelompok kontrol 259.9 (62.8) dan kelompok intervensi 285.3 (38.3) meter. Sedangkan rerata kualitas hidup kelompok kontrol 48.3(15.5) dan kelompok intervensi 40.3(9.8). Lebih lanjut hasil uji menyatakan tidak terdapat perbedaan rerata kapasitas fungsional (tabel 2). Setelah mendapatkan perlakuan dengan HBET selama 4 minggu kapasitas fungsional kelompok kontrol dan kelompok intervensi mengalami peningkatan, yaitu 290.2(70.9) dan 315.8(41.5). Hasil uji statistik juga menunjukkan adanya perbedaan yang bermakna antara kapasitas fungsional sebelum dan setelah perlakuan dengan HBET pada kelompok kontrol maupun kelompok intervensi. Hasil uji statistik perbandingan kapasitas fungsional setelah perlakukan antara kelompok kontrol dan intervensi menunjukkan p value 0.311 (á=0.05). ini berarti tidak terdapat perbedaan yang bermakna kapasitas fungsional antara kelompok kontrol dan kelompok intervensi setelah perlakuan, walaupun kelompok intervensi mempunyai rerata kapasitas fungsional yang lebih baik.

Tabel 1. Karakteristik responden kelompok kontrol dan intervensi – nilai merupakan mean (SD)

Variabel	Kontrol (n=11)	Intervensi (n=12)
Usia	58.45 (3.77)	60 (2.55)
IMT	22.20 (2.04)	22.02 (2.69)
6Penyebab HF		
HT (n)	2	2
IC (n)	1	2
HT&IC (n)	8	8

IMT : index masa tubuh; HT: hipertensi; IC: iskhemia cardiomiopathi; HT&IC: hipertensi & iskhemia cardiomiopathi

Tabel 2. Kapasitas fungsional responden gagal jantung sebelum dan setelah dilakukan perlakuan dengan HBET. – nilai merupakan mean (SD)

Tabel 2. Kapasitas fungsional responden gagal jantung sebelum dan setelah dilakukan perlakuan dengan HBET. – nilai merupakan mean (SD)

Va-riabel	Kontrol		Perlakuan	
	Pre	Post	Pre	Post
KF	259.9(62.8)	290.2(70.9)*	285.3(38.3)	315.8(41.5)*

*$p<0.05$ antara pre dan post.

KF: kapasitas fungsional

Peningkatan kapasitas fungsional terjadi karena membaiknya fungsi pompa otot karena banyak faktor, diantaranya terapi medis, edukasi perubahan gaya hidup dan aktivitas fisik berupa pekerjaan sehari-hari di rumah. Responden mendapat terapi standart yang berupa medikasi dengan golongan *ACE Inhibitor*, Blokade terapeutik terhadap RAAS memicu terjadinya vasodilatasi dan diuresis yang menghasilkan penurunan tekanan darah dan menurunan kerja jantung. kondisi ini secara signifikan mengurangi mortalitas dan mordibitas pasien gagal jantung. Beta bloker, inotropik, dan diuretik merupakan kombinasi dengan *ACE Inhibitor* untuk terapi gagal jantung. (Schub and Caple, 2010).

Hasil studi yang dilakukan Kjekshus et al (1992) dalam Nicholson (2007), mempelajari tentang penggunaan enalapril pada gagal jantung mendapatkan hasil adanya perbaikan mortalitas, meningkatkan kapasitas fungsional, memperbaiki toleransi latihan, menurunkan ukuran jantung, dan penggunaan obat yang lebih sedikit. Hasil *randomized* *control trials* yang melibatkan sekitar 15.000 pasien dengan berbagai derajad pasien gagal jantung menunjukkan pola yang konsisten bahwa *ACE inhibitor* menguntungkan untuk gagal jantung. *ACE inhibitor* secara signifikan menguntungkan bila digunakan pada pasien gagal jantung yang bergejala dan tidak bergejala (Nicholson, 2007; European Society of Cardiology, 2008).

Responden mendapatkan edukasi tentang perubahan gaya hidup yang meliputi diit rendah garam, pembatasan cairan 1-1.5 liter/24 jam, diit rendah kolesterol, menghentikan konsumsi alkohol dan rokok, edukasi untuk tetap melakukan aktivitas fisik setelah di rumah. Perubahan gaya hidup ini sangat menunjang keberhasilan terapi medikasi yang telah dijalankan. Kepatuhan responden menjadi kunci keberhasilan perubahan gaya hidup. Ketidakpatuhan responden dalam terapi gagal jantung merupakan hal yang sering terjadi, diperkirakan 40-60 tidak patuh terhadap pengobatan dan 43-93 % tidak patuh terhadap perubahan gaya hidup (Schub & Cabrera, 2010). Rendahnya kepatuhan ini mengakibatkan tingginya angka dirawat ulang pada pasien gagal jantung.

Responden melakukan aktivitas rutin harian di rumah sesuai dengan kemampuannya. Aktivitas yang rutin ini dapat dianggap sebagai bentuk latihan fisik yang diwujudkan dalam bentuk aktivitas sehari-hari. Sebagian besar aktivitas yang dilakukannya berupa kegiatan jalan kaki, membersihkan rumput dan bersepeda menuju tempat kerja merupakan bentuk dari latihan aerobic dan pembebanan. Metode ini terbukti efektif untuk tetap menjaga bahkan meningkatkan kemampuan fungsional. Ini didukung oleh Myers (2008), tipe latihan fisik yang sesuai bagi pasien gagal jantung adalah aerobik yang bersifat dinamis dan latihan tahanan ringan.

Latihan fisik pada gagal jantung sedang menjadi topik yang sering didiskusikan untuk menjadi bagian dari terapi standar pasien gagal jantung. Perubahan fisiologis, psikologis dan muskuloskeletal akibat latihan fisik dilaporkan dapat meningkatkan kapasitas fungsional. Latihan fisik pada gagal jantung memfasilitasi adaptasi fisiologis otot-otot yang dilatih untuk meningkatkan pengambilan oksigen, menurunkan *oxidative stress*, meningkatkan *enzime aerobic* dan meningkatkan jumlah serabut otot tipe I (McKelvie, 2008). Latihan fisik juga dapat meningkatkan volume *cytocrome oxidase-positive* mitokondria, mitokondria baik yang dapat memproduksi *adenisone triphosphat*. Selama latihan fisik berlangsung endotel pembuluh darah juga melepaskan *vasodilating factor*, seperti *nitrit oxide*. Perbaikan aliran darah ini berkontribusi terhadap penurunan tahanan pembuluh darah perifer, peningkatan ejeksi fraksi, dan perbaikan *stroke volume*. Latihan juga dapat memperbaiki pembuluh darah perifer yang berakibat meningkatkan aliran darah koroner (Hwang, Redfern, & Alison, 2008; McKelvie, 2008).

McKelvie (2008) menyatakan bahwa latihan fisik dapat meminimalkan gejala, meningkatkan toleransi latihan, kualitas hidup, dan memberikan efek yang memuaskan bagi kesembuhan pasien. Latihan fisik yang dilakukan di rumah juga terbukti dapat meningkatkan kapasitas latihan, *self efficacy*, dan menurunkan angka dirawat ulang. *HBET* diketahui secara positif meningkatkan kapasitas fisik, menurunkan berat badan, memperbaiki kontrol syaraf otonom, fungsi endotel pembuluh darah, dan peningkatan kapasitas oksidasi otot skelet (Hwang, Redfern & Alison, 2008).

Beberapa faktor yang berkontribusi terhadap ketidak adekuatan latihan fisik adalah peresepan latihan fisik, penyesuaian peresepan fisik dan latihan yang terintegrasi. Peresepan latihan fisik pada pasien gagal jantung yang adekuat harusnya mencakup komponen frekuensi, intensitas, durasi dan mode latihan fisik. Penyesuaian peresepan latihan fisik dan bersifat individu sangat diperlukan untuk mendapatkan hasil latihan fisik yang optimal, karena tidak ada formula atau program terbaik untuk semua pasien atau seseorang pada semua periode waktu. Program latihan yang terintegrasi yang dimulai saat pasien stabil dan masih dirawat di rumah sakit, dilanjutkan dengan latihan fisik terfokus di rumah sakit setelah pasien pulang dan dilanjutkan secara mandiri dengan HBET.

Latihan fisik yang dilakukan dalam penelitian ini adalah *aerobic* berupa jalan kaki, dengan durasi 30 menit selama 1 bulan, frekuensi 3 kali dalam 1 minggu, intensitas 40-60 % *heart rate reserve*. Formula ini menurut beberapa jurnal ilmiah dapat memberikan efek positif dan aman bagi pasien gagal jantung. Dalam penelitian ini tes untuk mengukur kemampuan awal pasien dilakukan dengan 6MWT, dengan parameter pencapaian menggunakan nadi pasien. Berdasarkan rata-rata usia denyut nadi target adalah 106-118x/menit, sedangkan rata-rata denyut nadi responden setelah pre test adalah 104x permenit, skala fatigue 12 dan dispneu 13 (skala borg 6-20). Ini berarti bahwa responden hampir mencapai kondisi ideal beban yang diharapkan oleh peneliti.

Durasi latihan fisik selama 30 menit dengan periode waktu 1 bulan merupakan waktu yang sangat singkat untuk proses adaptasi fisiologis terhadap latihan fisik pada gagal jantung. Waktu ideal yang disarankan untuk dapat memberikan efek yang optimal adalah 3-6 bulan. Frekuensi latihan 3 kali dalam 1 minggu merupakan kondisi minimal yang mampu memberikan efek positif terhadap fungsi jantung (Mandic, Riess, Haykowsky, 2006; Myers, 2007). Trend yang berkembang saat ini adalah sesering mungkin (tiap hari) sesuai dengan kemampuan pasien. Selain itu diperlukan penyesuaian yang bersifat individual dan kontinyu untuk memastikan bahwa pasien berada dalam rentang target yang diharapkan.

Latihan fisik yang diberikan oleh peneliti ini tidak menjadi bagian integral dari rehabilitasi gagal jantung dari rumah sakit sehingga persiapan untuk latihan fisik di rumah tidak dilakukan oleh pihak rumah sakit. Responden tidak di latih untuk melakukan aktivitas sejak dini, bahkan cenderung disarankan untuk banyak beristirahat. Responden tidak mendapatkan informasi mengenai latihan fisik yang harus diikuti untuk mempertahankan atau meningkatkan kapasitas fungsionalnya akibat tidak tersedianya fasilitas dan sumber daya manusia.

Menurut beberapa hasil penelitian ilmiah yang tidak dapat melaporkan adanya perbedaan kapasitas fungsional setelah *home based exercise training*, hal ini terjadi karena beberapa faktor yang berkontribusi diantaranya intensitas latihan, durasi latihan dan perbedaan usia (Hwang, Redfern, Alison, 2008). Jolly et al (2007) mengatakan bahwa protokol latihan fisik yang bervariasi, ukuran sampel kecil, dan latar belakang penyebab gagal jantung heterogen, *follow up* yang minimal dapat berkontribusi menyebabkan efek *home based exercise training* tidak optimal.

Perbaikan level toleransi latihan pasien gagal jantung dapat menjadi salah satu penentu perbaikan kualitas hidup responden gagal jantung. kondisi ini juga akan berdampak ke kehidupan sosial pasien gagal jantung, mereka akan lebih banyak bersosialisasi dan bertemu dengan orang lain. Hal ini didukung oleh adanya korelasi antara kapasitas fungsional dengan kualitas hidup dengan P value 0.018 (á=0.05), kekuatan hubungan sedang (r = 0.487) dengan arah negatif. Ini berarti bahwa semakin tinggi kapasitas fungsional akan semakin minimal gejala fisik yang dialami oleh pasien gagal jantung.

KESIMPULAN DAN SARAN

Latihan fisik pada pasien gagal jantung stabil merupakan suatu prosedur yang aman dan bermanfaat. Latihan fisik ini terbukti dapat meningkatkan kapasitas fungsional pasien gagal jantung. Latihan fisik ini hendaknya menjadi bagian integral program rehabilitasi pasien gagal jantung setelah pulang dari rumah sakit sehingga hasilnya lebih baik dan dapat diwujudkan menjadi aktifitas kesukaan pasien sehingga menurunkan angka ketidakpatuhan.

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CLINICS

ORIGINAL ARTICLE

Home-based training program in patients with chronic heart failure and reduced ejection fraction: a randomized pilot study

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OBJECTIVES: We aimed to compare the effects of home-and center-based exercise training programs on functional capacity, inspiratory muscle strength, daily physical activity level, and quality of life (QoL) in patients with chronic heart failure (CHF) over a 12-week period.

METHODS: This study included 23 patients with CHF (left ventricular ejection fraction 31 ± 6%) randomized to a home-based (n=11) or center-based (n=12) program. Patients underwent 12 weeks of aerobic training (60%–70% heart rate reserve): walking for the home-based and supervised cycling for the center-based group, both combined with resistance training (50% of 1 maximum repetition). At baseline and after 12 weeks of training, we assessed cardiopulmonary test variables, 6-min walk test distance (6 MWD), steps/day with accelerometry, and QoL (Minnesota Living with Heart Failure questionnaire). Maximal inspiratory pressure and handgrip strength were measured at baseline and after 4, 8, and 12 weeks of training. ClinicalTrials.gov: NCT03615157.

RESULTS: There were no adverse events during training in either group. The home- and center-based training groups obtained similar improvements in peak oxygen uptake, maximal ventilation, and 6 MWD. However, there were significant between-group differences: center-based training was more effective in improving maximal inspiratory pressure (p=0.042), number of steps/day (p=0.001), and QoL (p=0.039).

CONCLUSIONS: Home-based training is safe and can be an alternative to improve the exercise capacity of patients with stable CHF. However, center-based training was superior in improving inspiratory muscle strength, QoL, and daily physical activity.

KEYWORDS: Cardiac Rehabilitation; Telerehabilitation; Heart Failure; Endurance Training; Resistance Training; Exercise.

INTRODUCTION

Chronic heart failure (CHF), the end stage of several cardiac diseases, is increasing worldwide (1). Patients with this syndrome display symptoms such as dyspnea, fatigue, and exercise intolerance that limit their activities in daily life (2). Physical exercise improves functional capacity, quality of life (QoL), and inspiratory muscle strength and reduces cardiac events and hospitalizations in patients with CHF (3,4). However, center-based exercise adherence depends on factors such as time expenditure, accessibility limitations, financial costs, work and/or domestic commitments, and restricted availability of cardiac rehabilitation centers (5), particularly in low-and middle-income countries (6). With the advent of the coronavirus 2019 pandemic, when social distancing is necessary to prevent transmission, traditional center-based cardiac rehabilitation has become more limited (7,8).

Home-based training can be an alternative to supervised training for patients with stable CHF (9). Several home-based programs have been reported in the literature. Some of these comprised education, phone call support, and instructions that can be combined with resistance exercises (10), aerobic exercises, walking (11-13), or using a cycle ergometer or treadmill (14). Other home-based programs have combined

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aerobic and resistance exercises (15), and some have added telemonitoring to walking (16) or resistance exercises (17). Compared with non-training, home-based programs have shown benefits for exercise capacity (12,14) and QoL (12-15). Compared with traditional center-based training, home-based programs with telemonitoring have demonstrated similar results for exercise capacity, QoL, and exercise safety in patients with CHF (16,17).

In this respect, the use of home-based training programs as an easy, simple, and low-cost alternative to supervised center-based training for patients with stable CHF may be useful, especially in poor and middle-income countries. In the present study, we hypothesized that a simple and easy-to-perform unsupervised home-based training program may have similar effects to its traditional supervised center-based counterpart. We aimed to compare the effects of a home-based with a center-based training program on exercise capacity, physical activity level, QoL, and treatment adherence in patients with CHF.

MATERIALS AND METHODS

Trial design

This randomized, controlled, open-label, pilot trial was approved by the University of Sao Paulo Medical School Ethics Committee (reference 411/14) and Dante Pazzanese Institute of Cardiology Ethics Committee (reference 4536), which followed the ethical guidelines of the Declaration of Helsinki. Patients were randomized using sealed envelopes in a 1:1 allocation after written consent was obtained. ClinicalTrials.gov: NCT03615157.

Participants

Patients aged >18 years with CHF, New York Heart Association (NYHA) functional class II or III (18), and left ventricular ejection fraction of <40% were recruited consecutively from a list of new patients at the HF outpatient of the Dante Pazzanese Institute of Cardiology, from April 2015 to April 2018. The exclusion criteria were patients with new-onset atrial fibrillation or atrial flutter, complex ventricular arrhythmia at rest or presenting with exertion (19), acute or decompensated HF, pulmonary hypertension (pulmonary artery systolic pressure >35 mmHg), any orthopedic, cognitive, or neurological problems that could affect functional capacity measures, respiratory infection in the previous 30 days, and peripheral oxygenation of <92% in ambient air at rest.

Interventions

Following the baseline cardiopulmonary exercise test (CPX), patients were randomized to a home- or center-based training group (Figure 1). Considering the aerobic training, both groups used the same target heart rate (HR) of 60%–70% of the HR reserve (difference between maximum HR at CPX and resting HR) and patients were instructed to maintain their perceived exertion between 10 and 14 of the Borg scale (19). Each subject in both groups used a HR monitor (Polar FT1TM, Polar Electro Oy, Kempele, Finland) over the 12-week training period to ensure the target intensity of aerobic exercise and to avoid work overload. Additionally, both groups also performed resistance exercises at 50% of one repetition maximum (1RM), which was assessed and revised once a month. The 1RM test was performed according to the guidelines of the American College of Sports Medicine (20).

Home-based training comprised walking (three times a week for 30 min) in which patients were instructed to maintain the target HR, combined with resistance exercises guided by an illustrated instruction manual for the upper limbs (elbow flexion and extension, and shoulder flexion and abduction) and lower limbs (hip flexion, extension and abduction, knee extension, and plantar flexion) using free weights. The exercise intensity to initiate the program was one set of ten repetitions that followed a final progression to three sets of ten repetitions for each exercise with 50% of 1RM adjusted monthly over the training period. Free weights were provided for each patient according to the assessments. The patients were trained at least once per month with physiotherapist supervision, and the adherence and HR reached during the walks were monitored on a diary filled by the patients. Furthermore, the researcher made weekly phone calls to stimulate patients to continue performing daily exercises, to screen exercise adherence, and to answer possible doubts.

Center-based training took place at a cardiac rehabilitation facility of a cardiac hospital. The training program was

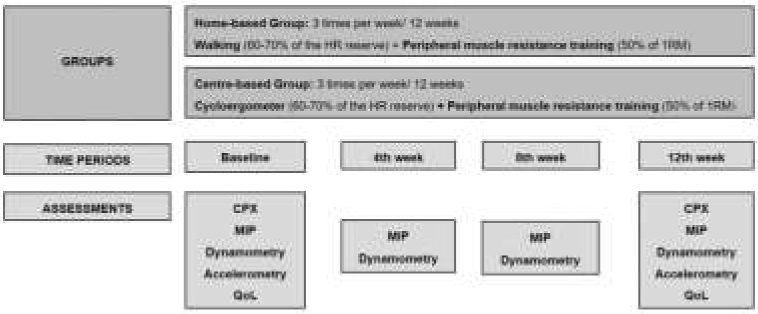

Figure 1 - Study design of interventions and assessments. CPX, cardiopulmonary test; HR, heart rate; 1RM, one repetition maximum; MIP, maximal inspiratory pressure; QoL, quality of life.

supervised by physiotherapists and comprised cycle ergometer exercises (three times a week for 30 min) to maintain the target HR, and resistance exercises for the upper and lower limbs. A physiotherapist recorded the patients adherence to each session.

Outcome measures

Anthropometric data, NYHA functional class, HF etiology, cardiac rhythm (24-h Holter, CardioLight, Cardios®, São Paulo, Brazil), presence of comorbidities, smoking status, and the use of medications were collected at baseline.

Assessments of exercise capacity

Exercise capacity was assessed using the CPX measures and the 6-min walk (6 MW) test at baseline and after the 12-week training period. Patients were instructed to have a light breakfast 2h before exercise capacity assessments, to take their medication, and to abstain from consuming caffeine-containing beverages, tea, and alcohol. The tests were performed between 8 a.m. and 11 a.m.

CPX was performed in a controlled environment (23°C room temperature and 55%–60% relative humidity) by blinded physicians and analyzed according to the European Society of Cardiology Guidelines (21). For this study, CPX was performed on a treadmill using a modified Balke ramp protocol at 2.0–3.4 mph (Trackmaster®, Full Vision Inc, KS, USA). Oxygen consumption (VO_2), carbon dioxide output (VCO_2), and minute ventilation (VE) were measured continuously breath-by-breath, with the aid of a gas exchange analysis system (Ultima™ CardiO2®, MGC Diagnostics Corp, MN, USA). A 12-lead electrocardiogram continuously monitored HR and cardiac rhythm throughout the test.

The 6 MW test was performed on a different day than the CPX. Patients were instructed to walk as fast as possible for 6 min in a 30-m corridor. We used verbal stimulation with standardized phrases every minute, as recommended by the American Thoracic Society guidelines (22). To avoid the learning effect, two tests were performed on the same day, with a minimum interval of 30 min. The test with the longest distance was used for the statistical analysis.

Assessments of respiratory and peripheral muscle strength

Respiratory and peripheral muscle strength were monitored at baseline and after 4, 8, and 12 weeks of training. The maximum value of three consecutive repetitions of each test was recorded. The inspiratory muscle strength assessment followed American Thoracic Society guidelines (23). Maximal inspiratory pressure was assessed using an analog pressure manometer with a range of ± 120 cmH_2O (WIKA DO BRASIL, Sao Paulo, Brazil). Patients sat in a chair with back support and inhaled forcefully and as quickly as possible in a mouthpiece with a 2 mm leak to avoid glottal closure. The maximal inspiratory pressure was measured at the residual volume. The results are presented as absolute values expressed in cmH_2O. Inspiratory muscle weakness was defined as a predicted (24) maximal inspiratory pressure of $<70\%$ (25).

Peripheral muscle strength was assessed using dominant handgrip strength measured by an analog dynamometer (Jamar Hydraulic Hand Dynamometer, Sammons Preston Inc., Illinois, USA). The procedure followed the recommendations of the American Society of Hand Therapists (26).

Assessments of QoL, physical activity, and sedentary behavior

Self-reported cardiac disease-specific QoL was assessed at baseline and after 12 weeks of training using the Minnesota Living with Heart Failure Questionnaire (MLHF) (27), in which higher scores represent worse QoL. We also used a validated version of the Short-Form 36 Questionnaire (SF-36) (28), which has eight sub-dimensions analysis ranging from 0 to 100, with lower scores representing worse health-related QoL levels.

For self-reported physical activity level, we used the International Physical Activity Questionnaire (IPAQ)-long form (29), which classifies subjects as sedentary, irregularly active, active, and very active.

We also performed objective measurements of physical activity and sedentary behavior using accelerometers at baseline and after the 12-week training period. Patients wore the device (GT3X Triaxial accelerometer, ActiGraph, FL, US) over their dominant hip for 24h over 9 consecutive days, except when bathing or swimming. For the data to be valid, patients had to wear the device for at least 10 h/day for 3 days. Data were recorded at a frequency of 30 Hz and sample intervals of 60-s epochs. Using the software (Actilife5, ActiGraph, FL, USA), we validated the wear time, converted units (counts) into steps, and classification of physical activity intensities using the Freedson energy expenditure algorithm (30). Sedentary behavior was assessed using sedentary bouts (no activity for more than 10 consecutive minutes) and total sedentary behavior per day. We also assessed the number of steps per day and time spent per day engaging in light and moderate-vigorous activity. Additionally, patients completed a daily report to ensure the wear time of the accelerometer.

Statistical analyses

This was a pilot study with an expected small sample size. In the present study, we aimed to examine the feasibility of two exercise training programs for use in a larger-scale study. We did not estimate the effect size because of the inherent data imprecision from small samples (31).

We used Minitab® Statistical Software (version 17; State College, PA, USA) and R package (version 3.4.3; Vienna, Austria) for statistical analyses. At baseline, intergroup comparisons of anthropometric data, NYHA functional class, HF etiology, cardiac rhythm, presence of comorbidities, smoking status, and the use of medications were conducted using the Mann-Whitney test or the chi-squared test. To evaluate the effects of time and group × time interactions between the two randomized arms, we used non-parametric analysis and mixed linear models (32). When a group × time interaction was detected, Tukey's multiple comparison test was applied. The difference in means and 95% confidence intervals were calculated and showed when the effects of the time or group × time interaction were identified. A non-parametric two-way analysis of variance for repeated measures (33) was performed to compare the ordinal data of the IPAQ. A significance level of 0.05 was set for the hypothesis tests.

RESULTS

Twenty-nine patients were enrolled in the study; however, one patient died from a cardiovascular disorder before initiating the training program. Of the 28 patients, only 23

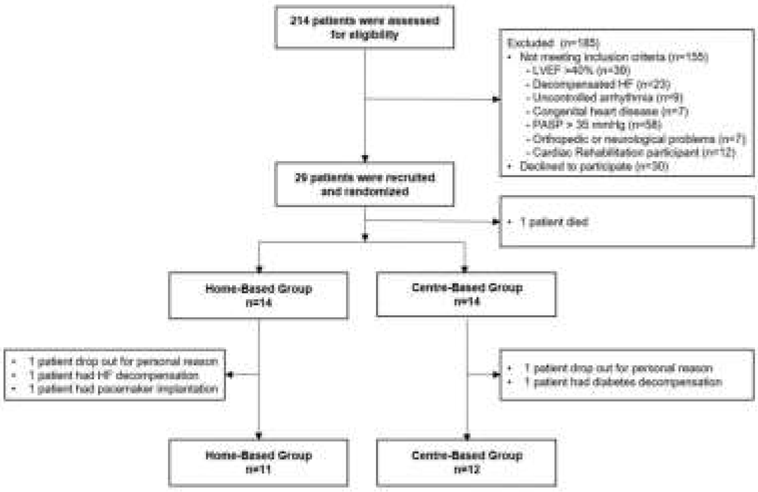

Figure 2 - Recruitment and intervention flowchart. HF, heart failure; LVEF, left ventricular ejection fraction; PASP, pulmonary artery systolic pressure.

completed the protocol (Figure 2). There were no cardio-respiratory arrests or deaths during either exercise training program.

Patient characteristics such as anthropometric data, NYHA functional class, HF etiology, cardiac rhythm, comorbidities, smoking status, and medication use were similar between the home-based and center-based groups at baseline (Table 1).

Exercise capacity assessed by the CPX was similar in both groups at baseline. All patients reached the target HR during both training programs, maintaining the workload between the aerobic and anaerobic thresholds. Home- and center-based training improved peak VO_2 (4% and 19%) and maximal ventilation (12% and 16%, respectively), without differences between the groups (Table 2).

At baseline, two home-based and four center-based patients exhibited inspiratory muscle weakness, and after training, only one patient in the center-based group had inspiratory muscle weakness. The center-based training group showed greater improvement in inspiratory muscle strength than their home-based counterpart (20% and 10%, respectively, *p*-value to between group difference=0.042; Figure 3). There were no changes in handgrip strength in either group.

At baseline, both groups were mostly sedentary and irregularly active. After training, the patients became more active according to the IPAQ analysis (Table 2). Using accelerometers, we observed a significant increase in the number of steps per day in the center-based compared with the home-based group (15% and -7%, respectively, *p*-value to between group difference=0.031). Additionally, the sedentary bout duration of the center- and home-based training groups declined by 14% and 9%, respectively, albeit with no changes in the number of sedentary bouts per day. The time spent per day in the different intensity categories of physical activity remained unchanged after both training programs (Table 2).

Health-related QoL improvement assessed by the MLHF was superior in the center-based group compared with the home-based group. Considering the SF-36 questionnaire results, the mental health component alone had a greater improvement in the center-based group than in the home-based group (Table 2).

The adherence rate in the home-based training program was observed by the daily report of the target HR registration in the diary and weekly phone calls, which showed 89% for walking and 94% for resistance exercises. In the center-based training program, the adherence rate was 94% for both groups. Adherence was similar in both groups (*p*=0.167).

DISCUSSION

In the present study, we compared an unsupervised home-based program (walking and resistance exercises) with a traditional center-based program (cycling and resistance exercises) in patients with CHF over a 12-week period. Peak VO_2 and 6 MW distance improved in both groups. However, the supervised center-based program was more effective in improving daily physical activity, inspiratory muscle strength, and QoL in patients with CHF. Furthermore, no adverse events were observed in either group.

Exercise plays a crucial role in cardiac rehabilitation. However, several factors can affect patient participation and adherence to center-based programs (5,6,8). Home-based training has emerged as a safe, simple, easy-to-perform, and low-cost alternative to center-based training, as reported by other studies using walking (11,13) and resistance exercises (10,17). Studies comparing home-based and traditional

Table 1 - Demographic and clinical characteristics of home-based and center-based groups.

	Home-based (n=11)	Center-based (n=12)	*p*-value
Age, mean ± SD (years)	59 ± 5	61 ± 7	0.733
Male, n (%)	5 (46)	9 (75)	0.147
BMI, mean ± SD (kg/m^2)	28 ± 4	27 ± 3	0.460
LVEF, mean ± SD (%)	31 ± 6	32 ± 6	0.711
NYHA II, n (%)	10 (91)	11 (92)	0.949
Duration of HF, mean ± SD (years)	11 ± 8	9 ± 9	0.557
Etiology, n (%)			0.278
Ischemic	2 (18)	6 (50)	0.265
Dilated	6 (55)	4 (33)	0.265
Cardiac rhythm, n (%)			0.339
Sinus rhythm	8 (73)	8 (67)	0.752
Atrial fibrillation	0 (0)	2 (17)	0.156
Implantable cardiac device	3 (27)	2 (17)	0.538
Other morbidities, n (%)			
Hypertension	10 (91)	10 (83)	0.590
Diabetes	3 (27)	3 (25)	0.901
Dyslipidemia	8 (73)	7 (58)	0.469
Myocardial infarction	4 (36)	6 (50)	0.510
Smoking status			0.265
Never smoker, n (%)	2 (18)	6 (50)	0.110
Ex-smoker, n (%)	8 (73)	5 (42)	0.133
Current smoker, n (%)	1 (9)	1 (8)	0.949
Mean pack-years	15 ± 16	11 ± 17	0.187
Medications, n (%)			
Amiodarone	4 (36)	4 (33)	0.879
Diuretics	10 (91)	9 (75)	0.315
Spironolactone	6 (55)	7 (58)	0.855
Beta blockers	11 (100)	12 (100)	0.999
Angiotensin-converting enzyme inhibitors	7 (64)	9 (65)	0.554
Angiotensin II receptor blockers	3 (27)	1 (8)	0.231
Digoxin	1 (9)	0 (0)	0.286
Anticoagulants	1 (9)	1 (8)	0.949
Antiplatelets	8 (73)	9 (75)	0.901
Statins	6 (55)	10 (83)	0.134

Continuous data: Mann-Whitney test; categorical data: chi-squared test BMI, body mass index; HF, heart failure; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association functional classification.

center-based programs have shown similar benefits for exercise capacity (13,16,17). Our study showed that both training programs had high adherence and improved exercise capacity over 12 weeks. Each program had barriers and facilitators to promote patient adherence. Our center-based program was performed at a public specialized cardiac center that required patients' fidelity to the program (a maximum of two absences/month were allowed). Additionally, multidisciplinary work teams and group activities may increase patients' confidence, motivation, and adherence. However, the costs and time for displacement, work release for center-based training, and personal dislike of group activities may limit adherence. On the other hand, the home-based program was freely adapted to the patients' schedules, and there were no additional transport costs and no need for work release. Nevertheless, home-based programs require patients' self-motivation, self-discipline, and schedule organization.

Although there was no statistical difference between the groups, the peak VO_2 improved by 19% in the center-based group and 4% in the home-based group. It is possible that participants did not keep up with the target HR during the 30 min of walking, despite the patients' HR and adherence being monitored by the researchers with weekly phone calls and a diary filled by them after daily exercises. Another possibility is that participants in the center-based group trained about 10% above the target HR using cycle ergometers, as CPX was performed on treadmills. However, all the patients were safely trained below 80% of the maximum HR. Additionally, it should be noted that our results are similar to those of other studies. Piotrowicz et al. (16) performed CPX in treadmills for prescription of aerobic exercise using cycle ergometers for supervised training and walking for home-based training. They found similar improvements in peak VO_2 in the supervised training (6%) and home-based groups (10%). Our protocol for both training programs included peripheral resistance training that was not prescribed in the study by Piotrowicz et al. (16). We raise the possibility that resistance training may also have contributed to this improvement in peak VO_2 in the center-based group (19%).

On the other hand, the submaximal exercise capacity, assessed by the 6 MW distance improved in both groups (the home-based and center-based groups improved by 40 m and 25 m, respectively). Only the home-based group reached the minimal important difference in the 6 MW distance of 36 m, which was previously reported in stable systolic CHF patients (34). The fact that walking was the modality of aerobic training in the home-based group may have favored the performance of the patients in the 6 MW test.

Respiratory and peripheral muscle weakness are abnormalities that lead to deleterious disuse atrophy and physical inactivity in CHF (25,35). Aerobic exercise may partially reverse weakness or improve the respiratory muscle strength (4,36). In our study, the improvement in inspiratory muscle strength in the center-based group was significantly superior

Table 2 - Functional capacity, physical activity level, and quality of life (mean values ± SD) at baseline and after 12 weeks in both groups using a mixed linear model and physical activity level assessed by the IPAQ, using a non-parametric two-way analysis of variance for repeated measures.

	Home-based n=11		Centre-based n=12		p-value Group × Time	p-value Group	p-value Time
	Baseline	12 weeks	Baseline	12 weeks			
Cardiopulmonary test							
Exercise time (s)	579 ± 144	645 ± 119	567 ± 148	645 ± 90	0.872	0.842	0.059
Peak heart rate (bpm)	117 ± 13	122 ± 18	116 ± 22	123 ± 26	0.848	0.985	0.268
Peak VO_2 (mL/kg/min)	19.2 ± 3.9	20.0 ± 4.2	19.5 ± 5.3	23.2 ± 6.1	0.085	0.448	0.011*
AT VO_2 (mL/kg/min)	13.3 ± 2.7	13.5 ± 3.7	12.9 ± 2.9	14.5 ± 3.7	0.367	0.920	0.235
VE/VCO_2 slope	31.6 ± 6.4	33.4 ± 5.8	31.4 ± 8.0	30.7 ± 8.1	0.196	0.594	0.657
Maximal ventilation (L/min)	51.4 ± 15.2	62.9 ± 28.2	58.8 ± 30.6	74.4 ± 33.7	0.775	0.429	0.015**
Oxygen pulse	12.1 ± 2.7	12.1 ± 3.1	13.6 ± 3.9	15.2 ± 4.0	0.108	0.129	0.130
Peak respiratory exchange ratio	1.1 ± 0.1	1.1 ± 0.1	1.1 ± 0.2	1.1 ± 0.1	0.868	0.852	0.781
6MW distance	460.7 ± 63.7	500.7 ± 86.1	513.1 ± 77.1	538.6 ± 72.3	0.805	0.013	0.002[‡]
Daily physical activity							
IPAQ							
Sedentary, n (%)	1 (10)	0 (0)	5 (42)	0 (10)	0.299	0.428	0.001
Irregularly active, n (%)	5 (45)	1 (10)	3 (25)	0 (10)			
Active, n (%)	5 (45)	10 (90)	4 (33)	12 (100)			
Accelerometry							
Number of steps per day	7335 ± 015	6873 ± 2819	5640 ± 2259	6541 ± 2225	0.001[1,2]	0.258	0.832
Number of sedentary bouts per day	18.5 ± 8.5	17.1 ± 6.7	23.9 ± 5.8	22.4 ± 6.9	0.972	0.062	0.214
Sedentary bouts length (mins/bout)	19.7 ± 10.0	18.1 ± 7.8	26.3 ± 7.3	23.0 ± 7.7	0.472	0.092	0.050
Sedentary time (mins/day)	539 ± 133	526 ± 111	625 ± 86	587 ± 140	0.581	0.113	0.266
Time spent on light activities (mins/day)	360 ± 118	333 ± 104	299 ± 87	323 ± 90	0.080	0.382	0.931
Time spent on moderate-vigorous activities (mins/day)	23 ± 16	23 ± 9	13 ± 9	21 ± 16	0.199	0.218	0.190
Health-related quality of life							
MLHF	29 ± 33	28 ± 33	35 ± 24	22 ± 13	0.039[#]	0.965	0.023
SF-36 – Mental Health	73 ± 32	68 ± 33	61 ± 23	72 ± 16	0.001[##]	0.848	0.342

AT, anaerobic threshold; IPAQ, International Physical Activity Questionnaire; MLHF, Minnesota Living with Heart Failure Questionnaire; SF-36, Short-Form 36 questionnaire; VCO_2, volume of exhaled carbon dioxide; VE, expiratory minute volume; VO_2, oxygen uptake; 6 MW, 6-min walk test. *Mean difference=2.2 (95% CI: 0.5–3.9); **Mean difference=12.9 (95% CI: 2.6–23.2); [‡] Mean difference=32.4 (95% CI: 16.5–48.4); [1]Home-based vs centre-based at baseline: p=0.001, Mean difference=2103 (95% CI: 1229–2977); [2]Centre-based at baseline vs 12 weeks: p=0.031, Mean difference=901 (95% CI: 67–1735); [#]Centre-based at baseline vs 12 weeks: p=0.014, Mean difference=13.2 (95% CI: 2.3–24.1); [##]p=0.031 Home-based vs centre-based at baseline and p=0.037 Centre-based at baseline vs 12 weeks, using Tukey multiple comparison procedure.

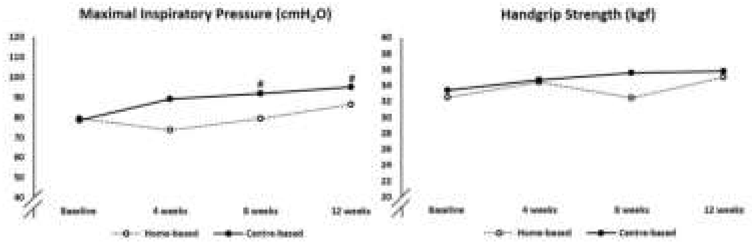

Figure 3 - Respiratory and peripheral muscle strength at baseline and at 4, 8, 12 weeks of training. # vs baseline, p=0.019 using Tukey's multiple comparison test.

to that in the home-based group (20% and 10%, respectively). Considering that the target HR was set based on the CPX performed on the treadmill, the center-based group may have been trained with a load 10% above the home-based group, as the training was on cycle ergometers. This intensity difference may have influenced the superior improvement in inspiratory muscle strength in the center-based group.

Handgrip strength in patients with CHF is a predictor of mortality when values are lower than 32.2 kgf (37). In the present study, at baseline, we observed that approximately 50% of patients in both groups had a handgrip strength less than this predictor value. After the 12-week training period, only 10%–15% of patients improved their upper muscle strength enough to exceed this clinical cutoff value. We raise the possibility that despite prescribing the recommended load for the strength exercises (50% of 1RM) (19) that was adjusted monthly for each patient, the training intensity and volume performed may not have promoted sufficient improvement in muscle strength. Additionally, aerobic exercises with the use of a cycle ergometer or walking did not directly contribute to the muscle strength of the upper limbs.

Both groups exhibited different walking behaviors (number of steps/day) at baseline and after training. At baseline, the center-based and home-based patients walked 5,640 and 7,345 steps/day, respectively. After training, the number of steps/day increased significantly in the center-based group (15%), although the home-based group showed no change. This improvement in the number of steps/day in the center-based group is associated with a change in the habit of these patients. As the training modality was the cycle ergometer, the center-based patients became more active in their daily living and not only in the exercise training sessions. Additionally, participants in the center-based training group had to move from home to the center three times per week, which could have affected the marked increase in their number of steps compared with participants in the home-based group.

Considering the self-report, most of our patients changed their perception of physical activity performance. At baseline, they were classified as sedentary or irregularly active by the IPAQ, and after the training programs, almost 100% of patients from both groups self-reported being active, which was corroborated by objective measurements showing reduction in sedentary behavior. This improvement in self-reported physical activity may be related to the amelioration in exercise capacity observed in both groups and consequently an increase in the patients' self-confidence in engaging in physical activity.

We found that the center-based group had a significant improvement in the QoL, observed by a 13-point decrease in the MLHF and an increase in the mental health component of the SF-36 questionnaire. The social involvement and multidisciplinary approach during the supervised exercises in the group may have contributed to this QoL improvement. Other studies did not observe differences between center-based and home-based training programs (10,17).

Our study had some limitations. This was a pilot, single-center study, with a final small sample size that may have been underpowered for accurate comparisons of functional capacity between the two programs. However, we used accurate and well-validated measures for the domains of interest. Despite the small number of patients in each group, we found both programs safe, as we did not have any reports or objective measurements of adverse events such as tachycardia, arrhythmia, or any signals or symptoms of low cardiac output. The home-based program might not reach the same efficiency in cardiovascular training as the center-based program, which showed greater improvements in maximal exercise capacity, inspiratory muscle strength, daily physical activity levels, and QoL. This is due to the inability to monitor the home-based patients in real time, as this technology is expensive, demands a good internet connection at patients' homes, and is limited and expensive in low-and middle-income countries. Furthermore, the center-based group training intensity was possibly approximately 10% above the home-based group, as the target HR was based on the CPX performed on the treadmill and the center-based group trained on the cycle ergometer.

From this pilot study, we suggest the use of technologies such as apps to monitor the number of steps and/or HR to assure training intensity and to objectively measure the patients' adherence, particularly in non-supervised training programs. We also suggest the use of a self-reported questionnaire on patients' motivation and satisfaction with exercise training programs to improve future personalized treatments.

CONCLUSIONS

This home-based program can be a simple, easy-to-perform, and safe alternative to improve the functional capacity of patients with stable CHF after specialized cardiac evaluation. However, center-based training was more effective in improving inspiratory muscle strength, daily physical activity, and QoL in patients with CHF.

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AUTHOR CONTRIBUTIONS

Andrade GN, Umeda IIK, and Nakagawa NK carried out, designed, and performed the experiments. Fuchs ARCN, Mastrocola LE, Rossi-Neto JM, Moreira DAR, and Oliveira PA assisted with some measurements. André CDS performed the statistical analyses. Andrade GN and Nakagawa NK wrote the manuscript with input from all authors. Andrade GN, Umeda IIK, Mastrocola LE, Oliveira PA, Cahalin LP, and Nakagawa NK contributed to the interpretation of the results. All authors participated in reviewing the manuscript and revising its intellectual and technical content.

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Home-based cardiac rehabilitation improves quality of life, aerobic capacity, and readmission rates in patients with chronic heart failure

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Abstract

Background: Exercise tolerance and cardiac output have a major impact on the quality of life (QOL) of patients experiencing heart failure (HF). Home-based cardiac rehabilitation can significantly improve not only exercise tolerance but also *peak oxygen uptake* ($\dot{V}O_2$ peak), and the QOL in patients with HF. The aim of this prospective study was to evaluate the beneficial effects of home-based cardiac rehabilitation on the quality of medical care in patients with chronic HF.

Methods: This study was a randomized prospective trial. HF patients with a left ventricular ejection fraction (LVEF) of less than 50% were included in this study. We randomly assigned patients to the control group (n = 18) and the interventional group (n = 19). Within the interventional group, we arranged individualized rehabilitation programs, including home-based cardiac rehabilitation, diet education, and management of daily activity over a 3-month period. Information such as general data, laboratory data, Cardiopulmonary Exercise Test (CPET) results, Six-minute Walk Test (6MWT) results, and the scores for the *Minnesota Living with Heart Failure Questionnaire (MLHFQ)* before and after the intervention, was collected from all patients in this study.

Results: Patients enrolled in the home-based cardiac rehabilitation programs displayed statistically significant improvement in VO_2 peak (18.2 ± 4.1 vs 20.9 ± 6.6 mL/kg/min, P = .02), maximal 6-Minute Walking Distance (6MWD) (421 ± 90 vs 462 ± 74 m, P = .03), anaerobic threshold (12.4 ± 2.5 vs 13.4 ± 2.6 mL/kg/min, P = .005), and QOL. In summary, patients receiving home-based cardiac rehabilitation experienced a 14.2% increase in VO_2 peak, a 37% increase in QOL score, and an improvement of 41 m on the 6MWD test. The 90-day readmission rate for patients reduced to 5% from 14% after receiving cardiac rehabilitation.

Conclusion: Home-based cardiac rehabilitation offered the most improved results in functional capacity, QOL, and a reduced the rate of readmission within 90 days.

Abbreviations: 6MWD = six-minute walk distance, 6MWT = six-minute walk test, AHA = American Heart Association, AT = anaerobic threshold, CABG = coronary artery bypass grafting, CI = cardiac index, CO = cardiac output, CPET = cardiopulmonary exercise test, CRT = cardiac resynchronization therapy, EF = ejection fraction, HF = heart failure, HFrEF = heart failure with reduced ejection fraction, ICON = left ventricle contractility index, IRB = Institutional Review Board, LVEF = left ventricle ejection fraction, MET = metabolic equivalent, MLHFQ = Minnesota Living With HF Questionnaire, NYHA Fc = New York Heart Association Functional Classification, VO_2 peak = peak oxygen uptake, QOL = quality of life, SV = stroke volume, SVR = systemic vascular resistance, TFI = thoracic fluid index.

Keywords: heart failure, home-based cardiac rehabilitation, quality of medical care

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Both YWC and CYW contributed equally to this article.

The principal investigator, JLH, had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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1. Introduction

Heart failure (HF) is a common yet complicated disease resulting from multiple etiologies, including coronary artery disease, hypertension, and certain metabolic disorders, leading to over 10,000 deaths each year in Taiwan.[1] HF is not curable and requires long-term evaluation and medical care. The incidence and prevalence rates of HF are increasing annually due to an aging populations, along with an increase in the prevalence rate of chronic systemic disorders, including hypertension, type 2 diabetes mellitus, and hyperlipidemia.[2,3] The average age of patients with HF is also decreasing. The therapeutic goal of HF is to avoid any aggravating symptoms, improve health-related quality of life (QOL), and decrease the costs of health care.[3,4]

Although several reports have suggested that the mortality rate of patients with HF is improving, the overall mortality rate still remains high. It has been estimated that more than 23% of rehospitalizations for HF[5] occur within 60 to 90 days, while less than 50% of patients with HF will survive for more than 5 years.[5–7] According to the registry data of the American Heart Association (AHA) for Projections, the prevalence of HF will increase by[7] 46% between 2012 and 2030, where patients with HF who are younger than 65 years old will have a 6 to 9 times greater risk of experiencing sudden cardiac death when compared with that of the general population.[7] The huge medical expense of HF leads to a heavy economic burden on both the patient's family and the health care system. Previous studies have shown that some symptoms of HF, including fatigue and dyspnea on exertion, make the daily activities of patients with HF intolerable.[3] Additionally, the aggravated symptoms of HF may cause depression, anxiety, and a compromised QOL for the patient.[8–10]

Several studies have shown that cardiopulmonary rehabilitation programs are both safe and effective for improving functional capacity and QOL, as well as for reducing the readmission rates and all-cause mortality of patients with HF.[1,11,12] The results of many clinical trials have established the benefits of hospital-based cardiac rehabilitation for patients with HF.[13–15] Home-based cardiac rehabilitation may be more accessible and acceptable when compared with hospital-based cardiac rehabilitation. However, home-based rehabilitation programs have not been widely studied and their training effects remain unclear.[1,13,16] Thus, the purpose of this study was to evaluate the effects of home-based cardiac rehabilitation on the improvement in functional capacity, enhancement in QOL, and the reduction in the rate of readmission for patients with HF.

2. Methods

2.1. Study design

This study was a prospective randomized study, where a total of 75 patients participated from June 2013 to March 2014 in Taichung Veterans General Hospital. We explained in detail the purpose and methods of the study to all staff, including cardiologists, physical therapists, and nurses. HF patients with a reduced ejection fraction (HFrEF) from the general ward, the intensive care unit, along with outpatients from the department of cardiology, all taken from a single medical center in central Taiwan were included in this study. The chosen patients were well informed of the content of the study and were required to sign a consent form before joining the study. Patients were eligible to withdraw from the study at any time. We randomly assigned patients into the control group and interventional group. Data were scrambled before being made available to researchers in order to ensure that individual identifying information at any level could not be obtained from the database. Clinical data of patients in the study were collected by both nurses and case managers within the cardiology department. The study then proceeded after obtaining permission from the hospital's Institutional Review Board (IRB).

2.2. Study subjects

HF patients in either the ward or outpatient department with a left ventricle ejection fraction (LVEF) of less than 50% were included in this study. We evaluated the functional stage of HF using the New York Heart Association Functional Classification (NYHA Fc) guidelines. Patients experiencing NYHA Fc IV, pregnancy, a high bedridden status, musculoskeletal system problems, and disabilities for which exercise is contraindicated, were excluded from this study. HF patients with a preserved ejection fraction (LVEF >50%) were excluded from this study due to a difficulty with performing a dedicated evaluation.

2.3. Measurements

All patients had to sign a consent form before joining this study. We recorded each patient's general data, including body height, body weight, and laboratory data during their admission and outpatient visits. We then evaluated each patients' QOL using the Minnesota Living With HF Questionnaire (*MLHFQ*) during the study period. We also monitored several parameters including VO_2 peak, anaerobic threshold (AT) through use of the Cardiopulmonary Exercise Test (CPET) and the 6 Minutes Walking Test (6MWT) in order to evaluate the change exercise tolerance during the study period. According to the data obtained from both the CPET and 6MWT, we designed an individualized home-based cardiac rehabilitation program according to each patient's willingness. In addition, we monitored the parameters of their hemodynamics status, including stroke volume (SV), LVEF, and thoracic fluid index (TFI), by using a noninvasive cardiac output monitor (Aesculon [Osypka Medical, Berlin, Germany]) during the study period. We measured the patients' general data and physiologic parameters in both groups at the beginning of the study and also 3 months later. Finally, we compared all collected data from both groups to evaluate both the change of exercise tolerance and QOL in the patients. Medications were not changed in any patient during the course of the study.

2.4. Exercise training protocol

In the interventional group, we collected general data and parameters using the same methods as we did for the control group. In addition, patients in the interventional group received outpatient cardiac rehabilitation for 1 week, before starting home-based cardiac rehabilitation. Home-based cardiac rehabilitation was conducted by requesting the interventional group to carry out aerobic exercise at least 3 times per week, for a duration of at least 30 minutes each time. Each patient was required to perform cardiac rehabilitation with an intensity measuring 60% to 80% of peak heart rate, based on the results of his or her initial CPET. The required exercise intensity was measured subjectively using a Borg score of 12 to 13.[17] The types of exercises prescribed were based upon individual interests and abilities, and included walking (47.3%), jogging (5.4%), and stationary cycling (47.3%). The control group was instructed to maintain both their standard medical care and previous activity levels.

Regular home-based cardiac rehabilitation was to be performed for at least 3 months in the interventional group, and all data including CPET and 6MWD were collected after completion of the home-based cardiac rehabilitation. Medical education regarding HF was also provided by the nursing staff during admission and the case manager in the outpatient department both groups. We monitored patients through telephone interviews held every 2 weeks during the study period.

2.5. Statistical analysis

After collecting all data from patients in the study, it was then expressed as mean ± SD. Continuous variables were analyzed using 2-way analysis of variance (ANOVA), and a paired t test was used to compare group differences with baseline values. A P value <.05 was considered statistically significant. Calculations and statistical analyses were carried out using SPSS version 18.0 (SPSS Inc., Chicago, IL).

3. Results

Forty patients were randomly assigned to the control group, while 35 patients were randomly selected for the interventional group. In the control group, 3 patients died during the study period, 8 were lost during follow-up, while 11 had incomplete data at the end of the study. As a result, this total of 22 patients in the control group were excluded from the study. In the interventional group, 3 patients could not complete the cardiac rehabilitation course, 4 patients refused to receive the final test, and 9 were lost to follow-up. Therefore, a total of 16 patients in this group were excluded from the study. In the end, there were 18 HF cases in the control group and 19 HF cases in the interventional group. Within the interventional group, 6 of the 19 patients experienced ischemic cardiomyopathy, 2 patients had received coronary artery bypass grafting (CABG) surgery, while 9 of the 19 patients had received cardiac resynchronization therapy (CRT) before the start of the cardiac rehabilitation program. Within the control group, 3 of the 18 patients experienced ischemic cardiomyopathy, no patient had undergone CABG surgery, while 8 of 18 patients had received CRT. One patient in the control group had rheumatic heart disease with severe mitral stenosis and had received a mitral valve replacement before joining the study.

Table 1 summarizes the baseline characteristics of the patients. There were no statistically significant differences in age, NYHA Fc, etiology of HF, LVEF, VO_2 peak, AT, or metabolic equivalent (MET) between the control and intervention patients.

Table 1

Baseline characteristics of enrolled patients.

	Control (n = 18)	Intervention (n = 19)	P
Age, y, mean (SD)	60 ± 10	61 ± 11	.878
Sex: Male/female (n)	14/4	17/2	.405
Height, cm	163.3 ± 7.4	164 ± 8.5	.794
Weight, kg	67.8 ± 18.4	67.3 ± 11.9	.928
Body mass index, kg/m^2	25.2 ± 5.7	24.9 ± 2.6	.807
EF %, mean (SD)	32 ± 11	36 ± 9	.369
VO_2 peak, mL/kg/min	18.9 ± 4.1	18.2 ± 4.1	.595
MET	5.4 ± 1.2	5.5 ± 1.8	.920
AT, mL/kg/min	12.8 ± 2.9	12.4 ± 2.5	.640
ICM (n)	3	6	.501
DCM (n)	15	13	.501
CABG (n)	0	2	.486
MR: I/II/III (n)	6/9/1	6/6/4	.317
AR: I/II (n)	9/4	6/6	.567
CRT (n)	8	9	1
RHD (n)	1	0	.486

6MWD = 6-min walk distance (meter), AR = aortic regurgitation, AT = anaerobic threshold, CABG = coronary artery bypass grafting, CRT = cardiac resynchronization therapy, DCM = dilated cardiomyopathy, EF = ejection fraction, ICM = ischemic cardiomyopathy, MET = metabolic equivalent, MR = mitral regurgitation I = grade I, II = grade II, III = grade III, n = number of subjects, NYHA = New York Heart Association, VO_2peak = peak oxygen uptake, RHD = rheumatic heart disease, SD = standard deviation.

In the interventional group, the patients who had participated in the home-based cardiac rehabilitation program showed a significant improvement of VO_2 peak by a margin of 14.2% (18.2 ± 4.1 vs 20.9 ± 6.6 mL/kg/min, P = .02), when compared with baseline. The *MLHFQ* score and 6MWD also increased significantly by the amount of 37% (32.1 ± 10.8 vs 20.2 ± 8.6, P < .01), and 41 m in the interventional group (421 ± 90 vs 462 ± 74 m, P = .03), respectively. The AT of the interventional group also improved remarkably (12.4 ± 2.5 vs 13.4 ± 2.6 mL/kg/min, P = .005). In the control group, there were visible declines in both VO_2 peak and MET, but there were no notable changes in AT, 6MWD, and *MLHFQ* scores at the 3-month follow-up. Table 2 displays the changes in exercise tolerance and QOL in both groups.

Data from the noninvasive cardiac output monitor, cardiac index (CI), SV, TFI, Left Ventricle Contractility Index (ICON), and systemic vascular resistance (*SVR)* were measured. The data showed a significant decline in the TFI of both groups after 3 months of training (26.5 ± 4.4 vs 22.5 ± 4.1 1/kΩ, P = .001 for the interventional group, 27.2 ± 6.8 vs 22.2 ± 3.8 1/kΩ, P < .01 for the control group). Other parameters showed no remarkable

Table 2

The changes of exercise tolerance and quality of life in both groups.

	Control (N = 18)			Intervention (N = 19)		
Parameters	Pre	Post	P	Pre	Post	P
VO_2 peak, mL/kg/min	18.7 ± 4.2	16.5 ± 3.7	<.01	18.2 ± 4.1	20.9 ± 6.6	.02
METs	5.4 ± 1.2	4.7 ± 1.1	<.01	5.5 ± 1.8	6.0 ± 1.9	<.01
AT, mL/kg/min	12.8 ± 2.9	11.7 ± 4.2	.136	12.4 ± 2.5	13.4 ± 2.6	.005
6MWD, m	350 ± 107	344 ± 121	.43	421 ± 90	462 ± 74	.03
MLHFQ	44.4 ± 15.3	42.1 ± 14.0	.33	32.1 ± 10.8	20.2 ± 8.6	<.01

6MWD = 6-min walk distance (meter), AT = anaerobic threshold, METs = metabolic equivalent, MLHFQ = Minnesota Living with Heart Failure questionnaire, n = number of subjects, SD = standard deviation, VO_2 peak = peak oxygen uptake.

Table 3

The change in parameters of heart function in both group.

	Control (N = 18)			Intervention (N = 19)		
	Pre	Post	P	Pre	Post	P
CO, L/min	4.34 ± 0.95	4.36 ± 1.09	.45	4.13 ± 0.45	4.29 ± 0.67	.15
CI, L/min/m²	2.58 ± 0.54	2.54 ± 0.61	.46	2.43 ± 0.28	2.51 ± 0.39	.20
TFI, L/kΩ	27.2 ± 6.8	22.2 ± 3.8	<.01	26.5 ± 4.4	22.5 ± 4.1	.001
ICON	42.5 ± 19.5	40.3 ± 15.4	.15	41.8 ± 12.0	39.3 ± 11.3	.18
SVR, N.cm⁻⁵	1660 ± 534	1600 ± 441	.73	1680 ± 435	1726 ± 450	.78

CI = cardiac index, CO = cardiac output, ICON = Index of Contractility, n = number of subjects, SD = standard deviation, SVR = systemic vascular resistance, TFI = thoracic fluid index.

differences between the 2 groups. Table 3 summarizes the changes in the parameters of heart function in both groups.

According to data obtained from our hospital's database of patients' medical records, the readmission rate for HF within 1 year was 34%, and 14% within 90 days during the period 2011 to 2012. At the 3-month follow-up period, the interventional group showed a significant reduction in the readmission rate within 90 days, decreasing from the average rate of 14% to 5%. The home-based cardiac rehabilitation program thus lowered the readmission rate for HF by nearly 10% for this 90-day follow-up period.

In conclusion, home-based cardiac rehabilitation programs can not only improve a patient's aerobic capacity, but they can also lower the readmission rate of patients with HF. Furthermore, no adverse events were reported during the home-based rehabilitation program.

4. Discussion

4.1. Major findings

Our study demonstrates that home-based cardiac rehabilitation results in a statistically significant improvement in both $\dot{V}O_2$ peak and AT, which in turn was associated with improvements in functional capacity and QOL.

4.2. Improvement in VO_2 peak and anaerobic threshold

In our study, home-based cardiac rehabilitation was associated with a remarkable improvement in $\dot{V}O_2$ peak, AT, and QOL. That same result could also be observed in outpatient-based cardiac rehabilitation.[18,19] The improvement exercise tolerance patients with HFrEF can be well-explained by the improvement $\dot{V}O_2$ peak and AT. Nevertheless, previous studies have shown that approximately 20% to 50% of patients with HF are unable to comply with hospital-based cardiac rehabilitation programs in the first 3 to 6 months.[20] As a result, home-based cardiac rehabilitation programs are shown to be more convenient, and may be an acceptable alternative option for patients with chronic HF.[21] Such home-based programs may therefore be a more practical strategy for motivating patients to continue exercise.[22] Several published studies have shown that home-based exercise training could improve both $\dot{V}O_2$ peak and 6MWD.[1] This is similar to our results, which showed an improved $\dot{V}O_2$ peak of 2.7 mL/kg/min, an improved AT of 1.2 mL/kg/min, along with an improvement in 6MWD of 41 m.

4.3. Improvement in QOL

Several previous studies have shown that rehabilitation programs can lead to a statistically significant improvement in QOL for patients with HF.[20,21,24] However, it remains controversial whether home-based cardiac rehabilitation benefits QOL or not. According to the results of our study, we observed that patients in the interventional group showed a significantly improved QOL after 3 months' follow-up, compared with the control group. The improvement in QOL is also related to the improvement in exercise tolerance. In addition to the benefits that cardiac rehabilitation provides, a further advantage it has is the easy integration of a home-based cardiac rehabilitation into a patient's life. A home-based rehabilitation program has a lower impact on a patient's daily life. In contrast, there was a decrease in $\dot{V}O_2$ peak and AT in the control group, which did not show any improvement in QOL. These data may explain, at least in part, why patients enrolled in the home-based cardiac rehabilitation program displayed a better QOL.

4.4. Improvement in 6-minute walking distance (6MWD)

The 6MWD has been proposed as an easy, well-tolerated, and alternative method for evaluating functional capacity.[25] Previous studies have demonstrated that higher rates of death and hospitalization were found in HF patients with a 6MWD of less than 300 m.[26] We showed that a 6MWD greater than 300 m may indicate a better prognosis. The meta-analysis offered strong evidence that the 6MWD was responsive to change in clinical status following cardiac rehabilitation, with an estimated mean difference in distance of 60.43 m.[27] In our study, 6MWD results improved from 420 to 461 m after patients received home-based cardiac rehabilitation for 3 months. This increased distance of 41 m on the 6MWD test was associated with an increase in both $\dot{V}O_2$ peak and AT, after the home-based rehabilitation program.

4.5. Changes in heart function after rehabilitation

Previous studies have shown that exercise training offers no benefits toward heart function, including cardiac output, SV, and LVEF.[28,29] Only 1 published study showed there was significant improvement in LVEF in both hospital-based and home-based exercise programs.[30] However, the noninvasive cardiac output measurement data showed no significant change in our study. The results of this study were thus similar to the findings of previous research. Short-term, home-based cardiac rehabilitation no significant benefits to cardiac physiologic function. However, more long-term research is still required in order to evaluate the effects of such exercise programs on cardiac physiologic function. In our study, both groups experienced a lower TFI at 3 months, compared with that at the beginning of the study. Traditional treatment for HF, including medical therapy, diet education, and lifestyle modification, still provided benefits toward the control of fluid status in patients with HF. Although short-term rehabilitation had no effect on heart function, the improvement in both $\dot{V}O_2$ peak and AT may play an important role in functional capacity and QOL.

4.6. Limitations

A limited number of subjects, high rate of loss follow-up, and a predominantly male subject pool are the limitations within this study. In addition, the study period may have been too short to see the full benefits of cardiac rehabilitation on the improvement of heart function. Although our study shows the benefits home-based cardiac rehabilitation has on exercise tolerance and QOL, further long-term study is still needed in order to show the effects it has on heart functions.

5. Conclusion

Home-based cardiac rehabilitation increased $\dot{V}O_2$ peak by 14.2%, QOL by 37%, and 6MWD by 41 m, and reduced the rate of hospital readmission within the initial 90-day follow-up.

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Lampiran 2

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NIM : 18613182

PRODI DIII KEPERAWATAN

FAKULTAS ILMU KESEHATAN

UNIVERSITAS MUHAMMADIYAH PONOROGO

2020/2021

NO.	HARI/TANGGAL	REKOMENDASI	TANDA TANGAN
1.	08. Juli 2020	Judul kti	
2	08. Septomber	Bab 1 -Perbaiki justifikasi, kronologis solusi -lanjut Bab 2	
3.	22/9 2020	Bab I : Perbaiki Intro Bab 2 : konsep Intoleransi aktifitas konsep Askep blm ada	
4.	30/9 2020.	Bab I : Acc. Bab 2 : konsep Intoleransi aktifitas sdh ada. Konsep askep : yg dituliskan adalah secara teori milik pasien gagal jantung kongestif yg mengalami intoleransi aktifitas.	
5.	5/10 2020	Bab 2 : Perbaiki Bab 2 : Perbaiki Penulisan Dapus blm ada.	

NO.	HARI/TANGGAL	REKOMENDASI	TANDA TANGAN
6.	12/10 2020	Perbaiki Dapus - Konsul keseluruhan	
7.	15/10 2020	Perbaiki Dapus Persiap [illegible] untuk ujian proposal	
8.	21/5 2021	Cari artikel lagi yg sesuai dg masalah kep. yg diangkat.	
9.	7/6 2021	judulnya studi literatur tt intoleransi aktivitas pd pasien [illegible] ⇓ Cari [crossed out] di SIKI salah satu intervensi utama u/ mengatasi intoleransi aktivitas apa ? ⇓ Baru cari literatur /artikel yg sesuai ⇓ - Pengaruh ..... - Efektifitas	

NO.	HARI/TANGGAL	REKOMENDASI	TANDA TANGAN
10	25/6 2021	Artikel yg dijadikan film sesuai. Materi berupa literatur review shg tdk bisa melihat epidemiologinya	
11	8/7 2021.	jurnal Acc. Bab I – III : sesuaikan dg studi literatur.	
12	27/7 2021	perbaiki bab 2,3,4 dan dapus	
13.	30/7 2021	perbaiki abstrak dan konsul keseluruhan	
14	08/8 2021	Acc ujian KTI	

BUKU KEGIATAN BIMBINGAN

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PRODI DIII KEPERAWATAN

FAKULTAS ILMU KESEHATAN

UNIVERSITAS MUHAMMADIYAH PONOROGO

2020/2021

NO.	HARI/TANGGAL	REKOMENDASI	TANDA TANGAN
1.	07. Juli 2020	Judul KTI	[signature]
2.	28/9 2020	Bab 1 : LBM Revisi [illegible] : [illegible] [illegible] [illegible]	[signature]
3	28/9 2020	Revisi [illegible] - [illegible] - [illegible] - [illegible]	[signature]
4.	23/10 2020	[illegible] intervensi [illegible] revisi [illegible]	[signature]
5	5/11 2020	Acc ujian	[signature]

NO.	HARI/TANGGAL	REKOMENDASI	TANDA TANGAN
6.	28/6 2021	Penulisan artikel ok BI SIKI	[signature]
7.	1/7 2021	Lanjut analisis	[signature]
8.	12/7 2021	- Cek panduan analisis - Perbaiki kalimat yg ≠ sesuai aturan - Perbaiki cara analisis	[signature]
9	03/8 2021	Perbaiki kalimat, spasi	[signature]
10	12/8 2021	[illegible]	[signature]

NO.	HARI/TANGGAL	REKOMENDASI	TANDA TANGAN
11	13/8 2021	Acc ujian	[signature]