ESC HEART FAILURE
ESC Heart Failure 2018; **5**: 241–248
Published online 23 November 2017 in Wiley Online Library (wileyonlinelibrary.com) **DOI:** 10.1002/ehf2.12230

ORIGINAL RESEARCH ARTICLE

Peripheral muscle training with resistance exercise bands in patients with chronic heart failure. Long-term effects on walking distance and quality of life; a pilot study

Charlotta Lans[1,2]*, Åsa Cider[3,4], Eva Nylander[2,5] and Lars Brudin[2,6]

[1]*Department of Physiotherapy, Kalmar County Hospital, Kalmar, Sweden;* [2]*Department of Medical and Health Sciences, Linköping University, Linköping, Sweden;* [3]*Department of Health and Rehabilitation/Physiotherapy, Institute of Neuroscience and Physiology, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden;* [4]*Occupational Therapy and Physiotherapy, Sahlgrenska University Hospital, Gothenburg, Sweden;* [5]*Department of Clinical Physiology, Linköping University, Linköping, Sweden;* [6]*Department of Clinical Physiology, Kalmar County Hospital, Kalmar, Sweden*

Abstract

Aims This study aimed to describe a method of peripheral muscle training with resistance bands in patients with chronic heart failure (CHF) and to evaluate its effects on the 6 min walk test and quality of life up to 12 months using a home-based programme.

Methods and results Twenty-two patients with stable CHF (19 men and 3 women), mean age 63.2 years (SD 8.1), New York Heart Association class II–III were randomized to individual home-based training (HT group), or home-based training with a group-based start-up in a hospital setting (GT group). A 6 min walk test, the Minnesota Living with Heart Failure Questionnaire (MLHFQ), and Short Form with 36 items (SF-36) were administered at baseline and after 3, 6, 9, and 12 months. Exercise training resulted in statistically significant increased walking distance in both groups. The HT group increased on average 107 (80) m from baseline to 12 months, and the GT group by 100 (96) m. Health-related quality of life, measured with MLHFQ and SF-36, reached statistically significant improvements in both groups but at different time points. There were no statistically significant differences between groups on any parameters or follow-ups.

Conclusions Long-term home-based peripheral muscle training in patients with CHF, with or without an introductory period in a hospital setting, can be used for initial improvement and retention of walking distance and health-related quality of life.

Keywords 6 min walk test; Cardiac rehabilitation; Heart failure; Home rehabilitation; Long time follow-up; Quality of life

Received: 30 June 2016; Revised: 17 April 2017; Accepted: 25 September 2017
**Correspondence to: Charlotta Lans, Department of Physiotherapy, Kalmar County Hospital, Hus 48, 39185 Kalmar, Sweden. Tel: +46 480 81756; Fax: +46 480 448280. Email: charlotta.lans@ltkalmar.se*
This study was conducted at the Department of Physiotherapy at Kalmar County Hospital, Kalmar, Sweden.

Introduction

Exercise training in patients with chronic heart failure (CHF) can positively impact physical fitness and health-related quality of life[1,2] and is a class IA recommendation in both European and American guidelines.[3,4] Despite this, only a small portion of patients with CHF receive a customized, individual-based exercise training programme.[5] Poor physical fitness and impaired health-related quality of life are characteristic of patients with CHF and limit both their daily activities and exercise training.[6,7] Since effects of exercise vanish quickly during de-training,[8,9] exercise training needs to be continual and lifelong. Both short-term and long-term exercise programmes can be difficult for patients with CHF when symptoms such as dyspnoea and fatigue occur even at low physical activity levels.[10] This may, therefore, limit willingness to undertake an exercise training programme.[2,5,10] For these patients, a resistance training programme with, for example, elastic bands, may be an alternative. A resistance band is an elastic band with adjustable resistance, which allows the patient to vary its length to reach a submaximal force level in various muscle groups. Pu *et al*.[11] showed improvements in submaximal muscle endurance, achieved by progressive resistance training, which may be important from the patient's perspective, since most daily activities are performed at submaximal force levels. This suggests that peripheral muscle training (PMT) could improve daily life, such as walking distance and health-related quality of life.

In addition, many patients are unable to participate in an exercise training programme in a hospital setting, for example, due to economic or transportation issues.[10,12,13] For these patients, a home-based exercise training programme could represent an alternative.[2,14,15]

Most previous studies have evaluated exercise training programmes in a hospital setting for shorter limited periods.[16,17] A few studies with long-term follow-ups for a year or more have focused mainly on cycling or walking.[18,19] Studies on long-term follow-up in a home-based PMT are lacking. We have, therefore, modified a previously reported PMT programme, which included home-based training and elastic resistance bands.[20,21]

Our first aim was to describe the method of a 12-month home-based PMT programme with resistance bands, and to evaluate its effects on the 6 min walk test and health-related quality of life in patients with CHF. The second aim was to compare the effect of home-based vs. group-based training in an outpatient hospital setting (routine care at Kalmar County Hospital, Sweden) during the initial 3-month training period and subsequent follow-up period.

Methods

Study design and population

This is a prospective study of physical training in patients with CHF undergoing a home PMT programme using resistance exercise bands, with or without a start-up period of 3 months in a hospital setting.

Twenty-two patients with CHF were recruited from the outpatient cardiology clinic at Kalmar County Hospital, Sweden. Inclusion criteria were a CHF diagnosis > 3 months with stable drug therapy, New York Heart Association functional class II or III, a left ventricular ejection fraction < 40%, and an age ≤ 80 years (*Table 1*). Exclusion criteria were concomitant chronic diseases, for example, chronic obstructive pulmonary disease or diabetes, and physical or mental disorders limiting the ability to carry out tests and exercises included in this study.

The Regional Ethics Review Board, Linköping, Sweden, approved the study, and all included patients gave their written informed consent to participate. Following the completion of baseline testing, patients were randomized by choosing a sealed envelope (1:1 ratio without stratification) to one of the interventional groups. The investigation conforms to the principles outlined in the Declaration of Helsinki. Measures of exercise capacity and self-reported quality of life were performed before the exercise period and at the 3-, 6-, 9-, and 12-month follow-ups. A physiotherapist, not otherwise involved in the investigation and blinded to group belonging, tested the patients. All patients were asked to maintain their daily physical activities during the intervention period.

Intervention

The PMT regime consisted of training with resistance exercise bands [Resistive Elastic Product (REP)-band®, Magister Corporation, Chattanooga, USA], using an isolated muscle mass

Table 1 Baseline patient characteristics

	HT group	GT group	Difference *P*-value
n	10	12	
Age (years)			
Mean (SD)	62.2 (8.4)	64.0 (8.2)	
Median (range)	60 (50–80)	64 (51–79)	0.50
Gender (*n*; %)			
Male	9 (90)	10 (83)	
Female	1 (10)	2 (17)	1.00
Height (cm)			
Mean (SD)	176 (8)	175 (12)	0.58
Weight (kg)			
Mean (SD)	91 (26)	81 (13)	0.28
BMI (kg m^{-2})			
Mean (SD)	29.0 (7.6)	26.3 (2.3)	0.42
Smoking (*n*; %)			
Yes	0 (0)	2 (17)	
No	10 (100)	10 (83)	0.48
NYHA II/III (*n*; %)			
II	6 (60)	7 (58)	
III	4 (40)	5 (42)	1.00
EF %			
Mean (SD)	25.7 (9.1)	25.9 (9.2)	
Median (range)	26 (9–38)	26 (10–40)	0.97
Diagnosis			
Dilated cardiomyopathy	6	4	
Ischaemic heart disease	4	8	0.39
Medication			
ACE-inhibitor	8	12	0.19
AII-blocker	2	0	0.19
Diuretic	10	12	1.00
Beta-blocker	8	8	0.65
6MWT			
Distance in meters	396.5 (96.5)	392.1 (129.9)	0.82
MLHFQ			
Physical dimension 0–40	17.4 (12.4)	18.5 (8.6)	0.67
Emotional dimension 0–25	8.6 (8.0)	10.0 (4.3)	0.35
SF-36			
Physical dimension 0–100	54.1 (26.0)	45.3 (20.7)	0.31
Mental dimension 0–100	58.5 (23.7)	50.0 (21.1)	0.38

6MWT, 6 min walk test; ACE, angiotensin-converting enzyme; BMI, body mass index; EF, ejection fraction; GT group, group-based training group; HT group, home-based training group; MLHFQ, Minnesota Living with Heart Failure Questionnaire; NYHA, New York Heart Association classification; SF-36, Short Form with 36 items.

with a low load and high number of repetitions to increase peripheral circulation in a specific skeletal muscle while imposing only a low load on the cardio-respiratory system. All patients exercised with two elastic bands of different resistance levels for the arm and leg exercises. The load of each manoeuvre was individually adapted based on a heart rate restricted to exceed no more than 30 beats above the resting value,[20,21] as measured by a heart rate monitor (Polar®, Kempele, Finland). The PMT involved nine different muscle groups (*Table 2*). Each manoeuvre was repeated 30 times (one or two sets). At follow-up, the load could be adjusted, but patients could contact the physiotherapist at any time if necessary. Total exercise time per week was 120 min.

Home-based training group

Home-based training included exercises with the patient's body weight as resistance and the use of elastic bands. After introduction to the PMT programme, the home-based training group (HT group) was asked to exercise at home regularly three times a week, ~40 min per session (i.e. one set at three times a week). The patients were asked to fill in an exercise diary comprising date, duration of the session, and estimation of perceived exertion. Each patient had a single telephone follow-up with the physiotherapist during the first 3 months. The patients were asked if the exercise programme worked well and if there were any ambiguities concerning the exercise programme requiring attention.

Group-based training group

In the hospital setting, pulley, free weights, and body weight were used as resistance. During the first 3 months, the group-based training group (GT group) attended the 60 min PMT programme twice weekly (i.e. two sets at twice weekly) at the cardiac rehabilitation ward, as outpatients, under the supervision of a physiotherapist. After the initial supervised period, patients exercised at home in the same way as the HT group.

Outcome variables

Six minute walk test

All patients were instructed to walk as far as possible at their own pace for 6 min on an 80 m course (in a hospital corridor) with rest, if needed. The total walking distance was measured.[11] Heart rate was recorded before and after the test, and patients were asked to assess the rate of perceived exertion (RPE) 6–20 and feeling of breathlessness [category ratio (CR) 0–10] according to the Borg scales.[22] The patients performed a practice walk test to reduce the learning effect.

Quality of life

A validated and reliability tested Swedish version of the disease-specific Minnesota Living with Heart Failure Questionnaire (MLHFQ) was used. MLHFQ comprises two dimensions, one physical consisting of eight items, score 0–40, and one emotional consisting of five items, score 0–25.[23] A lower score reflects a better quality of life. The validated and reliability tested Swedish version of the health-related questionnaire Short Form with 36 items (SF-36 v1™)[24] was used to analyse variations in health-related quality of life during the test period. SF-36 v1™ comprises eight sub-dimensions, which were in turn weighted together into two dimensions, one physical and one mental. Items in each dimension are transformed into a scale ranging from 0 (worst health) to 100 (best health). SF-36 v1™ was completed together with the MLHFQ.

Adherence

Patients were asked to fill in an exercise diary to monitor adherence during the study year. The diary contained the number of sessions (weekly), duration of exercise, and the estimated perceived exertion during each exercise session. After the last follow-up at 12 months, patients were prompted to take responsibility for their own exercise.

Table 2 The peripheral muscle training programme

Warm up	**Exercise using own body weight**
The HT-group was told to warm up for 5–10 min by walking on the spot	Bilaterally in erect position
The GT-group warmed up for 12 min to music with exercises in sitting and standing positions	M. gastrocnemius
Exercises with free weights *or REP-band*	**Exercises with pulley *or REP-band***
Unilaterally standing or sitting	Bilaterally in erect position
M. biceps brachii	M. pectoralis major
Wrist extensor group	M. intercostalis
M. quadriceps	M. rhomboides
	M. triceps brachii
	M. gluteus maximus (unilaterally)
	Cool down for 5–10 min
	With stretching exercises in both groups

GT-group, group-based training group; HT-group, home-based training group; M., muscle; REP-band, resistive elastic product.

Statistics

The power calculation was based on previously published results from similar studies. Calculations on an expected increase of 20% in walking distance with an SD of 30% indicated that a total of 24 patients should be included. Since the GT group could not affect the number of training sessions per week (maximum 2) for the first 3 months, the frequency of weekly training sessions in the HT group was limited to a maximum of three as prescribed. There was no limitation during the remainder of the training period.

Before conducting the data analyses, missing follow-up data from two patients were estimated using the pooled mean value from each outcome from the missing follow-up occasion (mean imputation). Group differences at baseline were analysed using Fisher's exact test for categorical, and Mann–Whitney's U-test for continuous parameters, solely for descriptive purposes. The residuals of all presented variables were normally distributed, and repeated-measures ANOVA was used to compare changes over time with groups as categorical predictors, followed by Duncan's test in the case of significance. A level of $P < 0.05$ was considered statistically significant. The data were analysed in Statistica version 12 (StatSoft®, Tulsa, OK, USA).

Results

Patient characteristics

Patient characteristics and measurements at baseline were comparable (*Table 1*), and medical treatment was unchanged during the study period. All patients tolerated the exercise training well. Four patients were treated for heart failure in hospital for a few days, but this did not substantially affect the exercise training. One patient dropped out after 3 months and another after 6 months, both from the HT group: One developed lumbago and one lived too far away to attend. Thus, 10 patients were included in the HT group, and 12 in the GT group.

Longitudinal differences

Group differences

There were no statistically significant differences between the HT and GT groups regarding walking distance [the difference at 3 months was 26 m ($P = 0.62$), and at 6 months, 45 m ($P = 0.41$)] or quality of life before exercise or during the follow-up period.

Six minute walk test

The HT group increased their walking distance significantly ($P < 0.002$) from 396 m (96) at baseline to 464 m (118) at 3 months, on average 68 m (17%), and remained unchanged thereafter (*Figure 1*). Walking distance in the GT group also increased significantly ($P < 0.001$) from 393 m (130) at baseline to 490 m (108) at 3 months, an average improvement of 97 m (25%), and maintained the obtained walking distance up to 12 months. No differences were seen in perceived exertion (RPE 6–20) or perceived shortness of breath (CR-10). The resting heart rate or the heart rate from rest to exercise did not change significantly during the follow-up.

Quality of life

The GT group improved the physical dimension of disease-specific quality of life (MLHFQ), significantly at 3 months, which remained unchanged for up to 12 months. The emotional dimension also improved but reached statistical significance only at the 3- and 12-month follow-ups (*Figure 2*). Regarding the SF-36, both the physical and mental dimensions improved significantly at 3 months and remained unchanged thereafter (*Figure 2*). In the HT group, the disease-specific quality of life (MLHFQ) increased, although not significantly except for a statistically significant increase for the physical dimension at 6 and 9 months (*Figure 2*). The emotional dimension increased but was not significant at any of the follow-ups. The SF-36 improved significantly in the physical dimension at 12 months and in the mental dimension at 9 and 12 months (*Figure 2*).

Adherence to exercise

There were no differences between the groups for adherence according to the prescribed procedure from baseline to 3 months (maximum three and two times a week for the HT and GT group, respectively; *Figure 3*). Average adherence per week for the first 3 months was 80% [median three times per week (range 1.5–3.0)] and 100% [median two times per

Figure 1 Six minute walk test (6MWT). Mean values and 95% confidence interval for 6 min walking distance at baseline (BL) and during the follow-up period. GT, group-based training group; HT, home-based training group. Differences from baseline in each group $^{**}P \leq 0.01$, $^{***}P \leq 0.001$.

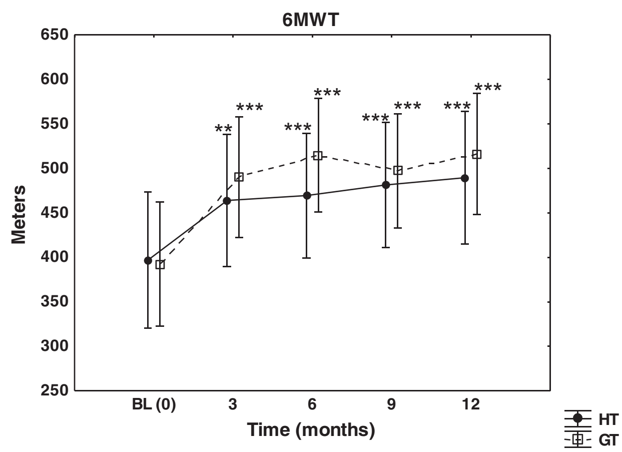
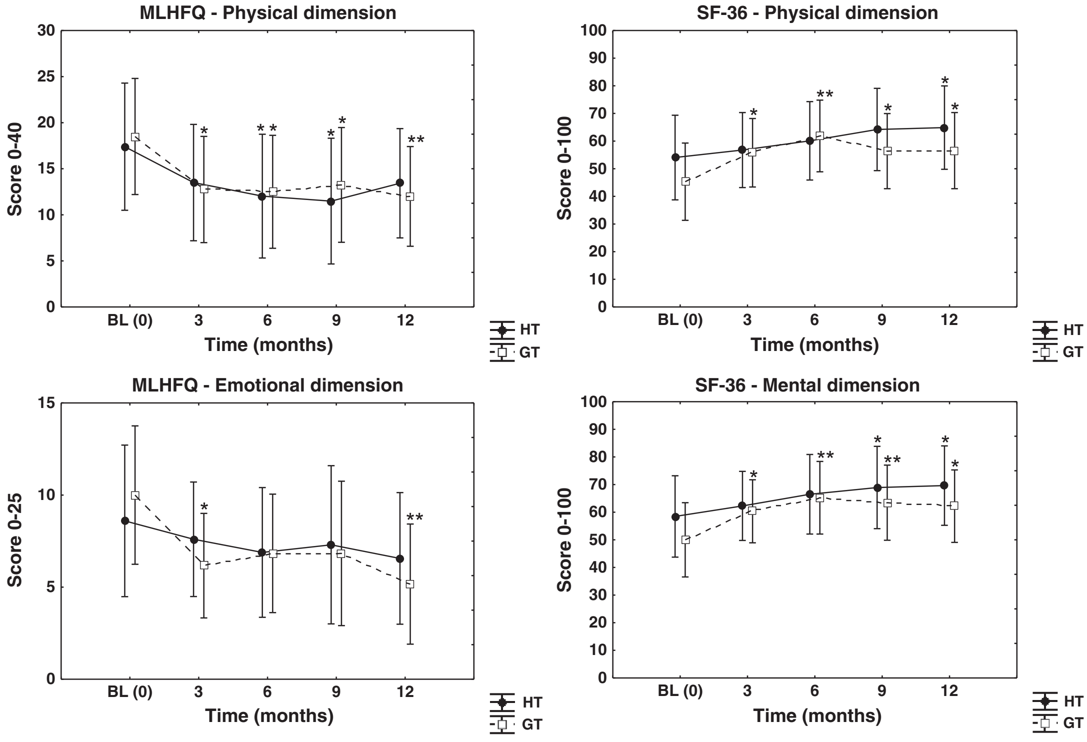
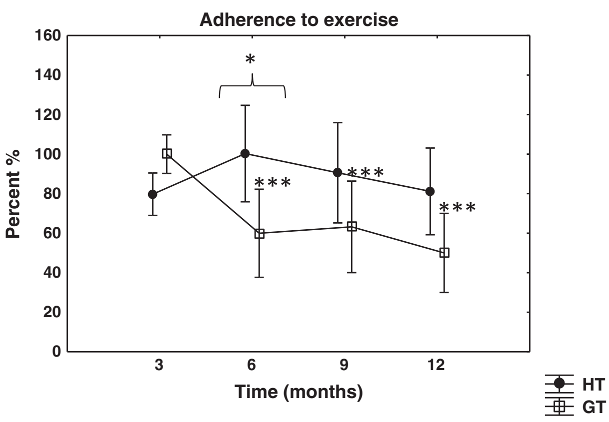


Figure 2 Quality of life. Physical and emotional/mental dimension of the Minnesota Living with Heart Failure Questionnaire (MLHFQ) and the Short Form with 36 items (SF-36) at baseline (BL) and during the follow-up period. Note that the two scales go in opposite directions. Mean and 95% confidence interval. GT, group-based training group; HT, home-based training group. Differences from baseline in each group *$P \leq 0.05$, **$P \leq 0.01$.



week (range 2–2)] of the prescribed number of exercise sessions in the HT and GT groups, respectively. The HT group significantly increased the number of exercise sessions per week at the 6-month follow-up ($P < 0.05$) and remained unchanged for 12 months. The GT group significantly reduced the number of weekly exercise sessions from 3 to 6 months ($P < 0.001$) and maintained the reduction for

Figure 3 Adherence to prescribed exercise. GT, group-based training group; HT, home-based training group. Difference from baseline ***$P \leq 0.001$ and difference between groups, *$P \leq 0.05$.



12 months. There was a statistically significant difference between the groups at the 6-month follow-up, $P = 0.017$. Between 3 and 6 months, the corresponding numbers were 100% [median 3.1 times per week (range 1.1–6.3)] in the HT group and 60% [median 1.5 times per week (range 0.8–3.0)] in the GT group. Adherence for 6–9 months in the HT group was 91% [median 2.8 times per week (range 0.8–6.3)] and in the GT group 63% [median 2.0 times per week (range 0.3–3.0)], and for the last follow-up period of 9–12 months, the numbers of training sessions were 81% [median 3.0 times per week (range 0.5–5.3)] in the HT group, and in the GT group 50% [median 1.6 times per week (range 0.5–2.1)].

Discussion

The major findings in this study were that PMT with REP bands, mainly at home, was effective in increasing walking distance and quality of life in patients with CHF. The improvement was achieved after 3 months and persisted for up to 12 months, with limited surveillance after the initial 3 months.

One group underwent a 3-month initial outpatient hospital-based exercise programme before the home-based exercise; the other group did not. The results showed a significant improvement for both groups in the 6 min walk distance (6MWD) that persisted for 12 months. Since the rate of perceived exertion and heart rate were unchanged, the increased 6MWD is most likely the result of increased work capacity.

The improved walking distance as a result of PMT in this study is in line with a study of Tyni-Lenné *et al.*,[25] showing increased walking distance (by 11%) after 8 weeks of PMT with elastic bands (two sets and 25 repetitions). Exercise training, in their study, was only in a hospital setting. A similar study by Safiyari-Hafizi *et al.*[26] also showed significantly improved walking distance by home-based training with elastic bands (15 repetitions and one to three sets) after 12 weeks. Their study, however, focused on a contained high-intensity, interval walking programme.[26] Gaffney *et al.*[21] suggested as early as 1981 that resistance exercise with a high number of repetitions may increase aerobic capacity and may be suitable for patients with poor physical fitness as seen in CHF. One reason for the improvement in aerobic capacity by PMT could be that patients have previously been highly inactive and were even recommended to live a quiet life. Increased breathlessness, onset of sympathetic drive, and vasoconstriction in CHF, even upon mild exertion, might be related to overactivity of the ergoreflex due to decreased metabolism in working muscles. PMT increases work capacity and tolerance, and one possible mechanism is improved peripheral muscle metabolism where acidosis and enhanced ergoreflex activity will be reduced.[7,27]

Several studies have shown that aerobic exercise training increases work capacity.[28] A problem for patients with CHF is breathlessness when walking or cycling. Such exercise can be hard to tolerate and can therefore lead to immobilization followed by muscle hypotrophy.[29] However, an isolated muscle can be exercised to fatigue without breathlessness significantly affected. This speaks for using a PMT programme in CHF patients.

Both the disease-specific and health-related quality of life improved significantly, at almost every follow-up in this study. Previous studies[25,26] have reported similar increases in the MLHFQ after 8 and 12 weeks of training with elastic bands.

In this study, both groups exercised as prescribed for the first 3 months. Between 3 and 12 months, they had fewer exercise sessions, which may reflect poor self-discipline and must be taken into account when judging the benefit of a home-based exercise programme. The GT group lowered their exercise frequency at home after the introductory period while the HT group did not. A reason for this could be that the GT group was accustomed to exercising twice a week, whereas the HT group was accustomed to three times weekly. We believe that patients chose to exercise as prescribed for the first period and had thus become accustomed to that level. However, despite the lower exercise frequency after the first 3 months, both groups maintained improvements, probably because they had become generally more active.

The EXERT-study[19] showed that 16% of the patients in the home-based exercise group attended <50% of sessions, and 14% did not attend any of the scheduled programme sessions. One of the reasons could be decreased motivation to exercise, suggesting that a home-based exercise programme needs constant follow-up.

The findings of the HF-ACTION study[18] support the efficacy and benefit of exercise training in patients with CHF. However, patients underwent aerobic exercise training (treadmill or cycle) at a rather moderate level (60–70% of heart rate reserve), and upper body exercises or strength training was not permitted during the supervised or home-based training period. Only 30% of the patients in the exercise group adhered to the prescribed programme. The authors of the HF-ACTION study suggest that the lack of adherence could be limitation due to the disease, co-morbidity, and/or diminishing motivation.[15,18] The declining adherence issue seems to be difficult to overcome.

Taylor *et al.*[30] showed, in a recently published review, that both home-based and centre-based rehabilitation was equally effective for improving clinical and health-related quality of life outcomes in patients with CHF, for the short term. Their conclusion was that the choice of participating in a traditional centre-based or home-based programme should reflect the preference of the patient. Finally, they highlight the need for studies focusing on home-based training rehabilitation for the long term.

Thus, when exercise programmes are required to be long term and ongoing, home-based interventions are necessary to provide continuous treatment for patients with CHF.[31,32] The progression of the effects of exercise training can be divided into three stages: (i) initial, (ii) improvement, and (iii) maintenance. Achieving the maintenance phase takes at least 6 months.[27,33] The maintenance phase should be lifelong. Implementation of supervised lifelong exercise training in traditional cardiac rehabilitation is desirable but most likely unfeasible.[15] Therefore, it is necessary to provide several training options, and develop and explore strategies for maintaining exercise training.

The PMT programme needs no complicated equipment. Individual gyms consisted of two resistive elastic bands (REP-band®) at home, and the PMT could be adjusted to the patient's ability and progress at any time. This study shows that a lifelong training programme that is easy to perform and can continue on holidays and weekends is achievable.

Since this was a relatively new mode of exercise for these patients, we chose to perform a pilot study and exclude concomitant chronic diseases, which entails a limitation when the number of patients in the two groups are small. Another limitation is the absence of a non-exercising control group. However, including a control group without exercise was not possible due to ethical considerations, since routine care in our hospital entails that all patients with CHF are offered cardiac rehabilitation, and that exercise training is a class IA recommendation in both European and American guidelines.[3,4]

Conclusions

Both regimens of PMT increased walking distance as well as quality of life, and improvements were sustained after 12 months with low external resources being required for the last 9 months of the study year. Home-based PMT provides the opportunity to exercise for patients unable or unwilling to participate in a hospital-based exercise programme. Patients with CHF could either start their exercise programme in a hospital setting or begin exercising directly at home after exercise instructions.

Acknowledgement

We would like to thank our colleague and friend, chief physician and MD Finn Landgren, who initiated and helped with this study but unfortunately passed away before the study's completion.

Conflict of interest

None declared.

Funding

This work was supported by the Kalmar County Research Committee.

References

1. Piepoli MF, Conraads V, Corra U, Dickstein K, Francis DP, Jaarsma T, McMurray J, Pieske B, Piotrowicz E, Schmid JP, Anker SD, Solal AC, Filippatos GS, Hoes AW, Gielen S, Giannuzzi P, Ponikowski PP. Exercise training in heart failure: from theory to practice. A consensus document of the Heart Failure Association and the European Association for Cardiovascular Prevention and Rehabilitation. *Eur J Heart Fail* 2011; **13**: 347–357.
2. McConnell TR. A review to develop an effective exercise training for heart failure patients. *Eura Medicophys* 2005; **41**: 49–56.
3. McMurray JJ, Adamopoulos S, Anker SD, Auricchio A, Bohm M, Dickstein K, Falk V, Filippatos G, Fonseca C, Gomez-Sanchez MA, Jaarsma T, Kober L, Lip GY, Maggioni AP, Parkhomenko A, Pieske BM, Popescu BA, Ronnevik PK, Rutten FH, Schwitter J, Seferovic P, Stepinska J, Trindade PT, Voors AA, Zannad F, Zeiher A, Bax JJ, Baumgartner H, Ceconi C, Dean V, Deaton C, Fagard R, Funck-Brentano C, Hasdai D, Hoes A, Kirchhof P, Knuuti J, Kolh P, McDonagh T, Moulin C, Reiner Z, Sechtem U, Sirnes PA, Tendera M, Torbicki A, Vahanian A, Windecker S, Bonet LA, Avraamides P, Ben Lamin HA, Brignole M, Coca A, Cowburn P, Dargie H, Elliott P, Flachskampf FA, Guida GF, Hardman S, Iung B, Merkely B, Mueller C, Nanas JN, Nielsen OW, Orn S, Parissis JT, Ponikowski P. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2012: The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. *Eur J Heart Fail* 2012; **14**: 803–869.
4. Pina IL, Apstein CS, Balady GJ, Belardinelli R, Chaitman BR, Duscha BD, Fletcher BJ, Fleg JL, Myers JN, Sullivan MJ. Exercise and heart failure: a statement from the American Heart Association Committee on exercise, rehabilitation, and prevention. *Circulation* 2003; **107**: 1210–1225.
5. Bjarnason-Wehrens B, McGee H, Zwisler AD, Piepoli MF, Benzer W, Schmid JP, Dendale P, Pogosova NG, Zdrenghea D, Niebauer J, Mendes M. Cardiac rehabilitation in Europe: results from the European Cardiac Rehabilitation Inventory Survey. *Eur J Cardiovasc Prev Rehabil* 2010; **17**: 410–418.
6. Chien CL, Lee CM, Wu YW, Chen TA, Wu YT. Home-based exercise increases exercise capacity but not quality of life in people with chronic heart failure: a systematic review. *Aust J Physiother* 2008; **54**: 87–93.
7. Piepoli MF. Exercise training in chronic heart failure: mechanisms and therapies. *Neth Hear J* 2013; **21**: 85–90.
8. Tyni-Lenne R, Gordon A, Europe E, Jansson E, Sylven C. Exercise-based rehabilitation improves skeletal muscle capacity, exercise tolerance, and quality of life in both women and men with chronic heart failure. *J Card Fail* 1998; **4**: 9–17.
9. Maiorana A, O'Driscoll G, Dembo L, Cheetham C, Goodman C, Taylor R, Green D. Effect of aerobic and resistance exercise training on vascular function in heart failure. *Am J Physiol Heart Circ Physiol* 2000; **279**: H1999–H2005.
10. Conraads VM, Deaton C, Piotrowicz E, Santaularia N, Tierney S, Piepoli MF, Pieske B, Schmid JP, Dickstein K, Ponikowski PP, Jaarsma T. Adherence of heart failure patients to exercise: barriers and possible solutions: a position statement of the Study Group on Exercise Training in Heart Failure of the Heart Failure Association of the European Society of Cardiology. *Eur J Heart Fail* 2012; **14**: 451–458.
11. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002; **166**: 111–117.
12. Oka RK, De Marco T, Haskell WL, Botvinick E, Dae MW, Bolen K, Chatterjee K. Impact of a home-based walking and resistance training program on quality of life in patients with heart failure. *Am J Cardiol* 2000; **85**: 365–369.
13. Dracup K, Evangelista LS, Hamilton MA, Erickson V, Hage A, Moriguchi J, Canary C, MacLellan WR, Fonarow GC. Effects of a home-based exercise program on clinical outcomes in heart failure. *Am Heart J* 2007; **154**: 877–883.
14. Hwang R, Marwick T. Efficacy of home-based exercise programmes for people with chronic heart failure: a meta-analysis. *Eur J Cardiovasc Prev Rehabil* 2009; **16**: 527–535.
15. Whellan DJ. Long-term exercise training and adherence: it is not just exercise. *J Am Coll Cardiol* 2012; **60**: 1529–1530.
16. Jankowska EA, Wegrzynowska K, Superlak M, Nowakowska K, Lazorczyk

M, Biel B, Kustrzycka-Kratochwil D, Piotrowska K, Banasiak W, Wozniewski M, Ponikowski P. The 12-week progressive quadriceps resistance training improves muscle strength, exercise capacity and quality of life in patients with stable chronic heart failure. *Int J Cardiol* 2008; **130**: 36–43.

17. Wisloff U, Stoylen A, Loennechen JP, Bruvold M, Rognmo O, Haram PM, Tjonna AE, Helgerud J, Slordahl SA, Lee SJ, Videm V, Bye A, Smith GL, Najjar SM, Ellingsen O, Skjaerpe T. Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. *Circulation* 2007; **115**: 3086–3094.
18. O'Connor CM, Whellan DJ, Lee KL, Keteyian SJ, Cooper LS, Ellis SJ, Leifer ES, Kraus WE, Kitzman DW, Blumenthal JA, Rendall DS, Miller NH, Fleg JL, Schulman KA, McKelvie RS, Zannad F, Pina IL. Efficacy and safety of exercise training in patients with chronic heart failure: HF-ACTION randomized controlled trial. *JAMA* 2009; **301**: 1439–1450.
19. McKelvie RS, Teo KK, Roberts R, McCartney N, Humen D, Montague T, Hendrican K, Yusuf S. Effects of exercise training in patients with heart failure: the Exercise Rehabilitation Trial (EXERT). *Am Heart J* 2002; **144**: 23–30.
20. Cider A, Tygesson H, Hedberg M, Seligman L, Wennerblom B, Sunnerhagen KS. Peripheral muscle training in patients with clinical signs of heart failure. *Scand J Rehabil Med* 1997; **29**: 121–127.
21. Gaffney FA, Grimby G, Danneskiold-Samsoe B, Halskov O. Adaptation to peripheral muscle training. *Scand J Rehabil Med* 1981; **13**: 11–16.
22. Borg GA. *Borg's Perceived Exertion and Pain Scale*. Human Kinetics; 1998.
23. Rector TS, Cohn JN. Assessment of patient outcome with the Minnesota Living with Heart Failure Questionnaire: reliability and validity during a randomized, double-blind, placebo-controlled trial of pimobendan. Pimobendan Multicenter Research Group. *Am Heart J* 1992; **124**: 1017–1025.
24. Sullivan M, Karlsson J, Ware JE Jr. The Swedish SF-36 Health Survey—I. Evaluation of data quality, scaling assumptions, reliability and construct validity across general populations in Sweden. *Soc Sci Med* 1995; **41**: 1349–1358.
25. Tyni-Lenne R, Dencker K, Gordon A, Jansson E, Sylven C. Comprehensive local muscle training increases aerobic working capacity and quality of life and decreases neurohormonal activation in patients with chronic heart failure. *Eur J Heart Fail* 2001; **3**: 47–52.
26. Safiyari-Hafizi H, Taunton J, Ignaszewski A, Warburton DE. The health benefits of a 12-week home-based interval training cardiac rehabilitation program in patients with heart failure. *Can J Cardiol* 2016.
27. Ko JK, McKelvie RS. The role of exercise training for patients with heart failure. *Eura Medicophys* 2005; **41**: 35–47.
28. van der Meer S, Zwerink M, van Brussel M, van der Valk P, Wajon E, van der Palen J. Effect of outpatient exercise training programmes in patients with chronic heart failure: a systematic review. *Eur J Prev Cardiol* 2012; **19**: 795–803.
29. Mentzer GG, Auseon AJ. Exercise capacity in chronic heart failure. *US Cardiol* 2012: 57–60.
30. Taylor RS, Dalal H, Jolly K, Zawada A, Dean SG, Cowie A, Norton RJ. Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev*; **2015**: Cd007130.
31. Smart N, Fang ZY, Marwick TH. A practical guide to exercise training for heart failure patients. *J Card Fail* 2003; **9**: 49–58.
32. Kavanagh T, Myers MG, Baigrie RS, Mertens DJ, Sawyer P, Shephard RJ. Quality of life and cardiorespiratory function in chronic heart failure: effects of 12 months' aerobic training. *Heart* 1996; **76**: 42–49.
33. Piepoli MF, Davos C, Francis DP, Coats AJ. Exercise training meta-analysis of trials in patients with chronic heart failure (ExTraMATCH). *BMJ* 2004; **328**: 189.