Exercise training and heart failure: a systematic review of current evidence

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SUMMARY

Chronic heart failure (CHF) is a growing public health problem. Current guidelines provide detailed information regarding pharmacotherapy but little guidance about the value of exercise/cardiac rehabilitation programmes for individuals with this condition. To investigate the effects of exercise training upon CHF patients, a systematic literature review was carried out of trials (from 1966 to December 2000) which used as their main outcome measures the effects of exercise training upon: (a) physical performance; or (b) quality of life; or (c) morbidity/mortality. Databases searched include: MedLine; Science Citation Index; Social Sciences Citation Index; BIDS, Bandolier*; Cochrane Database of Systematic Reviews (CDSR); NHS National Research Register (NRR); and Current Research in Britain (CRIB). Relevant bibliographic references from identified articles were also reviewed. Thirty-one trials were identified, comprising randomised controlled trials (RCTs) (14/31), randomised crossover trials (8/31), non-RCTs (2/31), and pre-test/post-test (7/31). Sample sizes were: 25 participants or fewer (20/31); 26 to 50 participants (7/31); 51 to 150 participants (4/31). Participants were predominantly younger, with a mean age in 23/31 studies of 65 years or less, and male. Patients with co-morbidities were often excluded. Positive effects were reported on physical performance (27/31), quality of life (11/16), mortality (1/31), and readmission rates (1/31). No cost-effectiveness analyses were identified.*

We conclude that short-term physical exercise training in selected subgroups of patients with CHF has physiological benefits and positive effects on quality of life. This review highlights the continuing problem of clinical trials that include participants who are not representative of the general population of CHF patients seen in primary care. Further investigation of the utility and applicability of exercise training is essential.

Keywords: *heart failure; exercise training; systematic review.*

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Introduction

HEART failure is a growing health problem worldwide with a poor prognosis and adverse effect upon patients' quality of life.[1] It results in high levels of health care utilisation, being responsible for approximately 120 000 hospital admissions annually in the United Kingdom.[2] It is therefore a disease of major economic significance with an estimated annual health care cost of £360 million.[3]

In view of the increasing incidence of heart failure, its negative impacts on quality of life,[1] and associated high levels of morbidity and mortality, there has been increasing interest in optimising its management. Treatment of heart failure has altered substantially over the preceding ten years and in recent times a plethora of guidelines relating to diagnosis and management have been published.[4-10] However, while these guidelines provide clear advice regarding pharmacotherapy of the illness, they provide little practical help to the cardiologist or primary care provider seeking guidance regarding the best advice to give heart failure patients on the subject of exercise. Traditionally, patients with congestive heart failure were recommended rest and it was widely believed that they should refrain from physical activity, owing to the potential damaging results it could cause.[11] This is certainly not the case today. Nowadays, there is an increasing consensus that exercise benefits the physical health of heart failure patients. In 1994, the Agency for Health Care Policy and Research published guidelines regarding the 'evaluation and care of patients with left- ventricular systolic dysfunction',[4] which concluded that there was insufficient evidence to promote supervised rehabilitation programmes at that time. In this paper, we describe a systematic review of the literature pertaining to the effects of exercise training with heart failure patients, to ascertain the current strength of evidence underlying the growing belief in the benefits of exercise for this patient population.

Method

Search strategy

Studies published between 1966 and December 2000 of the effect of exercise training with health failure patients were identified by searching the following electronic databases: MedLine; Science Citation Index; Social Sciences Citation Index; BIDS; *Bandolier*; Cochrane Database of Systematic Reviews (CDSR); NHS National Research Register (NRR); and Current Research in Britain (CRIB). No restriction was placed upon year of publication. Latest editions of key relevant journals not yet available on electronic databases were also scrutinised (such as *European Heart Journal*, *American Heart Journal*, *Journal of the American College of Cardiology*, the *American Journal of Medicine*, *Journal of the American Medical Association*, *British Medical Journal*,

HOW THIS FITS IN

What do we know?
Short-term physical exercise training in selected subgroups of patients with CHF has been shown to have physiological benefits and positive effects on quality of life. A reduction in hospital re-admission rates, improved morbidity, and a decline in mortality are the key indicators of the benefits of therapies for patients with heart failure. However, only one study has examined these outcome measures.

What does this paper add?
Larger, long-term trials are required which represent all heart failure patient groups in terms of age, sex, common co-morbidities, and location (i.e. hospital versus community-based) to clarify whether exercise has the desired physical and life-enhancing effects and thus should be widely recommended.

Heart, *Circulation*, *Circulation Research*, and *Hypertension*). The search terms used were: 'exercise training', 'physical training', 'aerobic', 'anaerobic', 'heart failure', 'left ventricular failure', and 'cardiac failure'. The reference lists of identified articles were also scrutinised for additional studies that conformed to the specified inclusion criteria. Titles, abstracts or both, identified by the outlined search strategy, were read by two reviewers who determined study eligibility. Full articles were then assessed for relevance. The search was restricted to English language papers, randomised controlled trials (RCTs), and clinical trials. Editorials, review papers, and discussion papers were excluded. Studies included had the effects of exercise training in terms of physical performance, quality of life or health care utilisation as the main outcome measures. Research studies with the following main outcome measures were excluded: the effects of drugs upon the physical performance of patients with heart failure; and the biomedical changes in patients with heart failure as a result of exercise training.

Selection criteria

RCTs are perceived as giving the most reliable evidence for inclusion in a systematic review[12] and a substantial number of the studies reported in this review are based upon a randomised controlled design. Nevertheless, owing to the limited number of studies that met with our search criteria, all published clinical trials were included in this review. Where any one study resulted in multiple publications, the principal paper with the greatest number of subjects focusing on exercise training with heart failure patients was reviewed (other publications based upon the same study sample are listed in the references).[13-17]

Outcome measures, data extraction, and analysis

Outcome measures examined were:

- improvements in physical performance, including: increased peak oxygen uptake; cardiac output; and aerobic capacity;
- quality of life;
- health care service utilisation;
- cost effectiveness; and
- mortality.

For all reported studies, the following information was recorded independently by two reviewers: bibliographic details — including country of origin, aims, study population, setting, subject selection criteria, information concerning the type of training provided, measurement tools used, outcome measures, and the study findings and conclusions. In addition, patient numbers, compliance and completion rates, the methodological approaches utilised, and other factors which could affect the validity of the results, including effect modifiers, were recorded.

Owing to the variations that existed in the study design, patient group, study setting, and outcome measures used in the studies, it was deemed inappropriate to conduct a meta-analysis. Presented here is a narrative synthesis of the studies obtained from the systematic review. The methodological quality of the RCTs was assessed using the Jadad Scale by two reviewers.[18] Disagreement between reviewers was resolved by consensus.

Results

General overview

Thirty-one studies met the defined selection criteria (Table 1). Of these, 14 were prospective RCTs,[19,21-24,27-33,46,47] eight were randomised crossover trials,[20,25,26,40,43,44,48,49] two were non-RCTs,[36,38] and seven were pre-test/post-test studies.[34,35,37,39,41,42,45] The provision of exercise training was, in the majority of cases, supervised and hospital-based, with data collection taking place in a hospital laboratory setting. Investigation of long-term effects was rare and 45% (14/31) of training programmes lasted eight weeks or less. Table 2 provides a summary of the methodological quality of the prospective RCTs. Only 43% (6/14) of the RCTs outlined their method of randomisation[19,20,27,36,37,47] and in many instances when descriptions were provided these were vague and incomplete (for example, no mention of the method of allocation). Seventy-four per cent (23/31) detailed their inclusion and, in some cases, exclusion criteria for patient recruitment,[19-21,23,24,26-30,33,35-40,43,44,46-49] but only 42% (13/31) provided information about the recruitment procedure adopted.[19,21,24,29,30,34,39,40,43,45-48] When the recruitment procedure was detailed, participants tended to represent convenience samples (for example, patients attending a particular clinic) or volunteers. Patients with other illnesses that frequently co-exist within the wider heart failure population were often excluded. For example, 26% (8/31) excluded patients with diabetes, while 52% (16/31) excluded individuals with chronic obstructive airways disease. The majority of studies were small, with 65% (20/31) having sample sizes of 25 participants or fewer; [20,21,23,25-29,31,34,35,37,39-41,44,45,47-49] 22% (7/31) with sample sizes of 26 to 50 participants;[19,22,24,30,36,38,46] and 13% (4/31) with sample sizes of 51 to 150 participants.[32,33,42,43]

Age of study participants

The annual incidence of heart failure increases exponential-

Table 1. Summary of the reviewed studies meeting the defined inclusion criteria.

Author	Study design	*n*	Mean (range) age in years	Sex	Activity	Duration	Frequency	Intensity as percentage of heart rate	Training period	Training effects
Belardinelli *et al*[33] (Italy)	Prospective RCT	99	C = 56; T = 53	M/F	B	40 minutes	3 times/week; 2 times/week	60% peak VO_2	52 weeks	Positive
Belardinelli *et al*[36] (Italy)	Non-RCT	27	57	M/F	B	30 minutes	3 times/week	40% peak O_2 uptake	8 weeks	Positive
Cider *et al*[9] (Sweden)	Prospective RCT	24	C = 65; T = 62	M/F	CT	15 minutes	3 times/week	60% of 1 rep maximum HR	20 weeks	Positive
Coats *et al*[26] (UK)	Randomised crossover trial	17	R = 61; T = 65	M	B	20 minutes	5 times/week	70–80% peak HR	8 weeks	Positive
Conn *et al*[34] (USA)	Pre-test/post-test	10	44–71	M/F (F = 1)	B	NS	3–5 times/week	70–80% maximum HR	8 weeks	Positive
Davey *et al*[20] (UK)	Randomised crossover trial	22	64	M	B	20 minutes	5 times/week	70–80% maximum HR	8 weeks	Positive
Delagardelle *et al*[45] (Luxembourg)	Pre-test/post-test	14	57	M/F	T, B	60 minutes	3 times/week	75% peak VO_2	24 weeks	Positive
European Heart Failure Group[42] (UK)	RCT	134	60.5	M/F	B, C	20/12 minutes	4–5 times/week	70–80% peak HR	6–16 weeks	Positive
Gordon *et al*[23] (Sweden)	Prospective RCT	21	60	M	KE	15 minutes	NS	TG1 = 35% abs peak; TG2 = 65–75% abs peak	8 weeks	Positive
Hambrecht *et al*[21] (Germany)	Prospective RCT	73	C = 54; T = 55	M	B	10 minutes; 20 minutes	4–6 times/week; once/day	70% peak VO_2 maximum	2 weeks (hospital); 24 weeks (home)	Positive
Jette *et al*[19] (Germany)	Prospective RCT	39	50.8	M	J, C, B, W	5/30/15/30–60 minutes	3–7 times/week	70–80% peak HR	4 weeks	Inconclusive
Johnson *et al*[31] (UK)	Prospective RCT	18	C = 63; T = 70	M/F	IM	15 minutes	2 times/daily	15% maximum IMP	8 weeks	Positive
Kavanagh *et al*[38] (Canada)	Non-RCT	30	C = 65; T = 62	M/F	W	NS	5 times/week	50–60% VO_2 maximum	52 weeks	Positive
Keteyian *et al*[24] (USA)	Prospective RCT	40	56	M	B, T, R, A	43 minutes	3 times/week	60–80% of HR	24 weeks	Positive
Kiilavuori *et al*[22] (Finland)	Prospective RCT	27	52	M/F (F = 1)	B, W, R, S	B = 30 minutes (supervised) HB = NS	B = 3 times/week (supervised); HB = NS	50–60% peak VO_2 later acc to HR	24 weeks	Positive
Koch *et al*[27] (France)	Prospective RCT	25	C = 64; T = 56	M/F	KB	90 minutes	3 times/week	NS	12 weeks	Positive
Maiorana *et al*[44] (Australia)	Randomised crossover trial	13	60	M	CT, B, T, IM	60 minutes	3 times/week	70–85% peak HR	8 weeks	Positive
Meyer *et al*[25] (Germany)	Randomised crossover trial	18	52	NS	B, W, T, E	B = 15 minutes, W = 10 minutes, T and E = 20 minutes	5 times/week; 3 times/week; 3 times/week	50% maximum WR	6 weeks	Positive
Oka *et al*[46] (USA)	Prospective RCT	40	Range = 30–76	M/F	T, RE	HB = 40–60 minutes	3 times/week (T); 2 times/week (RE)	70% peak HR	12 weeks	Positive

Continued

Table 1 (continued). Summary of the reviewed studies meeting the defined inclusion criteria.

Author	Study design	*n*	Mean (range) age in years	Sex	Activity	Duration	Frequency	Intensity as percentage of heart rate	Training period	Training effects
Owen *et al*[48] (UK)	Randomised crossover trial	22	C = 81; T = 81; R = 82	M/F	CT	10-minute warmup; 4.5 minutes' activity; 10-minute cool down	1 times/week	70% maximum of age predicted maximum pulse rate	12 weeks	Inconclusive
Quittan *et al*[47] (Austria)	Prospective RCT	25	C = 54; T = 57	M/F	B, SE	60 minutes	2 times/week; 3 times/week (from week five)	50% VO_2 maximum	12 weeks	Positive
Scalvini *et al*[35] (Italy)	Pre-test/ post-test	12	55/57	M	B	10 minutes, rising by 2 every 4th day	2 times/daily	70% maximum workload	5 weeks	Positive
Shepherd *et al*[39] (Canada)	Pre-test/ post-test	21	62	M/F	W	Not specified	5 times/week	60–70% peak O_2 uptake	16 weeks	Positive
Sullivan *et al*[41] (USA)	Pre-test/ post-test	16	54	NS	B, W, J	60 minutes	3–5 times/week	75% of peak VO_2	16–24 weeks	Positive
Taylor[49] (UK)	Randomised crossover trial	8	61	M	B	30 minutes	3 times/week	45–70% peak O_2	8 weeks	Inconclusive
Tyni-Lenne *et al*[28] (Sweden)	Prospective RCT	21	60	M	KE	15 minutes	3 times/week	70% peak performance	8 weeks	Positive
Tyni-Lenne *et al*[37] (Sweden)	Randomised crossover trial	24	M: 58/F: 60	M/F	KE	15 minutes	3 times/week	65–75% peak WR	8 weeks	Positive
Tyni-Lenne *et al*[40] (Sweden)	Randomised crossover trial	16	R = 63; T = 62	F	KE	15 minutes	3 times/week	65–75% baseline WR	16 weeks	Positive
Tyni-Lenne *et al*[43] (Sweden)	Randomised crossover trial	24	C = 62; Cycle = 62; KE = 64	M/F	B, KE	B = 20 minutes; KE = 32–36 minutes	3 times/week	60–75% peak WR	8 weeks	Positive
Wielenga *et al*[32] (Netherlands)	Prospective RCT	80	C = 65; T = 63	NS	W, B, BG	30	3 times/week	Target HR	12 weeks	Inconclusive
Willenheimer *et al*[30] (Sweden)	Prospective RCT	50	64	M/F	B	15 minutes every 6th week; 45 minutes every 10th week	2 times/week	80% maximum HR	16 weeks	Positive

RCT = randomised controlled trial; C = control group; T = training group; R = resting first group; M = male; F = female; J = jogging; C = calisthenics; B = cycle ergometer; W = walking; R = rowing; S = swimming; KE = knee extensor exercises; T = treadmill; KB = 'Koch bench'; CT = circuit training; IM = inspiratory muscle training; BG = ball games; RE = resistance exercises; SE = step exercises; E = exercises (not specified); HR = heart rate; WR = work rate; HB = home-based; NS = not specified.

Table 2. Methodological quality of prospective randomised controlled trials examining exercise for heart failure patients.

Study	Quality score					Total score (range = 0–5, poor quality <3)
	Was the study described as randomised?	Was the study described as double-blind?	Was there a description of withdrawals and dropouts?	Was randomisation appropriate?	Was blinding appropriate?	
Belardinelli *et al*[33]	Yes	No	Yes	No	No	2
Cider *et al*[29]	Yes	No	Yes	No	No	2
European Heart Failure Group[42]	Yes	No	Yes	Yes	No	3
Gordon *et al*[23]	Yes	No	Yes	No	No	2
Hambrecht *et al*[21]	Yes	No	Yes	Yes	No	3
Jette *et al*[19]	Yes	No	Yes	Yes	No	3
Johnson *et al*[31]	Yes	No	Yes	No	No	2
Keteyian *et al*[24]	Yes	No	Yes	Yes	No	3
Kiilavuori *et al*[22]	Yes	No	No	No	No	1
Koch *et al*[27]	Yes	No	Yes	Yes	No	3
Oka *et al*[46]	Yes	No	Yes	Yes	No	3
Quittan *et al*[47]	Yes	No	Yes	Yes	No	3
Sullivan *et al*[41]	Yes	No	Yes	Yes	No	3
Tyni-Lenne *et al*[28]	Yes	No	Yes	No	No	2
Wielenga *et al*[32]	Yes	No	Yes	No	No	2
Willenheimer *et al*[30]	Yes	Yes	Yes	No	No	3

ly with age, from a rate of two per thousand in the fifth decade of life to 50 per thousand in the eighth decade.[50] Even so, mean patient age was age below 65 years in 74% (23/31) of studies. Only two studies specifically examined age variation and how this might affect a patient's response to physical exercise.[30,48] Both studies suggested that physical exercise is safe and beneficial for 'older' chronic heart failure patients. Nevertheless, the former study[30] had a small sample, was short-term, and most participants were nearer to 70 years of age. Although the latter study[48] included 'older' patients (mean age = 81 years), they emphasised that further investigation was required regarding the benefits upon morbidity and mortality, ongoing compliance, and safety for this age group.

Sex of study participants

The overall prevalence of heart failure is reported to be similar in men and women[51-53] yet women were grossly under-represented in the studies. Sex distribution was reported in all but three studies.[25,32,41] Ten studies included males only,[19-21,23,24,26,28,35,44,49] with only one study focusing exclusively upon females.[40] In studies where both males and females were included there still existed a strong bias towards male participants (for example, male/female ratios of 26:1, 9:1, 5:1).[22,27,29-31,33,34,36-38,42,43,45,48] Of those studies that included both female and male patients with chronic heart failure, only two examined the differences that may exist between male and female chronic heart failure patients in their response to physical exercise.[30,37]

Patient compliance and completion

Completion and compliance rates were not recorded for five and 15 of the studies respectively. Fifteen studies cited completion rates for the exercise programmes as being between 90% and 100%[23,25,29,30,33,35-37,40-42,43,44,46,47] with 11 ranging between 50% and 89%.[19,21,24,26,27,31,38,39,45,48,49] Compliance rates were, again, quite favourable, with 12 studies reporting more than 80% compliance[24,28,32,33,37-40,42,43,45,48] and four studies reporting between 50% and 80% compliance.[21,26,29,30]

Nature and intensity of the exercise

The majority of studies used either a cycle ergometer,[20,21,26,30,31-36,49] or combined exercise programmes (such as cycle ergometer and/or walking and/or jogging and/or swimming, or circuit training).[19,22,24,25,27,29,32,41,42,43-47] Five studies focused upon anaerobic training in the form of knee-extensor or leg muscle training[23,28,31,37,40] and only two studies prescribed a walking programme.[38,39] None of the studies attempted to assess patients' acceptance of such exercise protocols and their ability to adopt such procedures on an individual long-term basis. A total of eight studies incorporated a home-based exercise component.[20-22,26,34,38,42,46] Seven provided patients with a cycle ergometer and/or treadmill for use in their home over a relatively short time period, with one study prescribing an individualised walking programme over a 52-week period. While choosing to implement an exercise training programme in patients' homes, none of the studies capitalised upon this approach by pro-

Table 3. Summary of reviewed studies, including a quality-of-life measure.

Author	Quality-of-life measurement	Implementation	Outcome
Belardinelli *et al*[33]	MinLWHFQ	Baseline and 2,14, 26 months	QoL score improved ($P<0.001$) in 'T' group after 2 months, remained stable at 12 months and follow-up.
Cider *et al*[29]	NHP/QLQ-HF	Baseline and study completion (20 weeks)	NHP: significant improvement found in 'C' group in social life, hobbies and holidays. QLQ-HF: No significant differences. (No *P*-values or CIs reported)
Coats *et al*[26]	Likert Scale	End of each study phase (i.e. 8 weeks training/ 8 weeks restricted activity)	Improvement in 'T' group for breathlessness ($P<0.01$) and fatigue ($P<0.001$), daily activities ($P<0.001$), ease of these activities ($P<0.01$). (No CIs reported)
Johnson *et al*[31]	CHFQ	Baseline and study completion (8 weeks)	No significant difference between group scores.
Kavanagh *et al*[38]	CHFQ/SG	Baseline and 16, 26, 52 weeks	CHFQ showed trends in improvement for 'T' group; fatigue ($P<0.001$), dyspnoea ($P<0.115$), emotional function ($P<0.132$), mastery ($P<0.149$) . SG = 14% improvement sustained over 52 weeks. (No CIs reported)
Koch *et al*[27]	Visual scale	Baseline and study completion (12 weeks)	Improvement estimate: 63% in 'T' group, spontaneous variation only 4% in 'C' group. (No *P*-values or CIs reported).
Oka *et al*[46]	CHFQ	Baseline and study completion (12 weeks)	'T' group. improvement in fatigue ($P = 0.02$), emotion ($P = 0.01$), sense of mastery (0.04). (No CIs reported)
Owen *et al*[48]	MinLWHFQ	Baseline and study completion (12/26 weeks)	No change in scores for 'C' or 'T' groups. (Scores not reported)
Quittan *et al*[47]	MOS SF-36	Baseline and study completion (12 weeks)	Improvement in 'T' group. for vitality ($P<0.0001$) physical role ($P<0.001$), physical ($P = 0.02$), and social functioning ($P = 0.0002$).
Shepherd *et al*[39]	CHFQ/SG	Baseline and study completion (16 weeks)	Improvement in 'T' group CHFQ scores: fatigue ($P<0.001$). SG showed 14% improvement ($P<0.0035$). (No CIs reported)
Tyni-Lenne *et al*[28]	SIP/SOC	Baseline and study completion (8 weeks)	SIP scores improved in 'T' group. ($P<0.03$–0.005). SOC scores did not differ.
Tyni-Lenne *et al*[37]	SIP/SOC	Baseline and study completion (8 weeks)	Overall SIP scores improved for men ($P<0.002$) and women ($P<0.005$). SOC scores showed slight improvement for women ($P<0.03$). (No CIs reported)
Tyni-Lenne *et al*[40]	SIP/SOC	Baseline and 8,16 weeks	SIP physical scores improved in 'T' group. ($P<0.04$). No change in SOC score. (No CIs reported)
Tyni-Lenne *et al*[43]	MinLWHFQ/ SIP/SOC	Baseline and study completion (8 weeks)	Improvement in MinLWHFQ scores (knee-extensor only $P<0.02$). No significant improvement in SIP or SOC. (No CIs reported)
Wielenga *et al*[32]	HPPQ/SAGWB	Baseline and study completion (12 weeks)	HPPQ: Marginal significant difference between 'C' and 'T' group ($P = 0.06$) SAGWB: higher for 'T' group. ($P<0.0001$) (No CIs reported)
Willenheimer *et al*[30]	D-F index/Global QoL/PA score	Baseline and study completion (16 weeks)	Global QoL improved in 'T' group. ($P<0.01$). In 'T' group. correlation found between D-F index and Global QoL ($r = 0.44$, $P<0.05$)

SIP = Sickness Impact Profile; SOC = Sense of Coherence Scale; NHP = Nottingham Health Profile; QLQ-HF = Quality of Life Questionnaire-Heart Failure; D-F index = Dyspnoea-Fatigue Index; Global QoL = Global Quality of Life; PA score = Physical Activity Score; CHFQ = Chronic Heart Failure Questionnaire; HPPQ = Heart Patients Psychological Questionnaire; SAGWB = Self-Assessment of General Well-Being; MinLWHFQ = Minnesota Living with Heart Failure Questionnaire; CHFQ = Chronic Heart Failure Questionnaire; SG = Standard Gamble Test; CIs = confidence intervals.

viding an account of the advantages and disadvantages of the procedure in comparison with hospital-based exercise training.

Outcome measures

The studies had diverse outcome measures (for example, lactic acidosis threshold, respiratory quotient, ventilatory threshold, ejection fraction, mean pulmonary artery pressure, peak oxygen uptake, cardiac output, blood pressure, citrate synthase, and anaerobic threshold). The most commonly recorded positive effects on physiological physical performance indicators were oxygen uptake (23/31), resting heart rate (15/31), maximal heart rate (11/31), sub-maximal heart rate (9/31), systolic blood pressure (8/31), and ventilation (8/31), and as shown in Table 3 only 52% (16/31) also measured quality of life.[26-33,37-40,43,46-48] Of these, positive effects on quality of life were reported in 69% (11/16). Studies incorporating a quality-of-life component varied widely in the approach and instrument used and in the results obtained. Only four studies considered the relationship between quality of life and physiological outcomes[33,38,39,47] Assuming that the short-term effects of exercise training are favourable, it is likely that patients will experience, and thus report, improvements in their quality of life. However, none of the available studies allowed for the assessment of the long-term impact of such exercise training upon patients' quality of life. Health care utilisation issues and mortality were addressed in only one study.[33]

This study found that mortality was lower in the training group (relative risk [RR] = 0.37, 95% confidence interval [CI] = 0.17 to 0.84; P = 0.01) and hospital readmission rates were higher in the control group (RR = 0.29, 95% CI = 0.11 to 0.84; P = 0.02). No cost-effectiveness analyses have, as yet, been published.

Discussion

The review indicates that the available literature regarding the effects of exercise training upon heart failure patients is encouraging. The published trials indicate that short-term physical exercise training in selected subgroups of patients with heart failure has physiological benefits and positive effects on quality of life, at least in the short term. In addition, favourable rates of completion and compliance were reported.

However, based on our review of the literature it would seem that most of the published research:

- presents short-term, laboratory-based assessments of heart failure patients and fails to consider the long-term impact of exercise programmes; that is, the ability for patients to adopt an exercise programme on their own, ideally with support from community-based health professionals, such as their primary care provider;
- utilises subgroups of heart failure patients, who do not reflect the general population of patients with heart failure, being predominantly younger males without common co-existing morbidities;
- is dominated by small-scale studies where the research subjects are often convenience samples rather than randomly selected;
- has focused upon the immediate physical effects of various exercise protocols rather than examining any long-term physical benefits, in terms of morbidity and mortality.

This systematic review is not without its limitations. Study authors and 'experts' in the field were not consulted, and the search was limited to the English language literature. Consequently, some published trials may have been overlooked. However, it is unlikely that the results of the review would be substantially altered unless any overlooked studies were long-term, included a large sample frame, and had an appropriate study design.

A reduction in hospital re-admission rates, improved morbidity, and a decline in mortality are the key indicators of the benefits of therapies for patients with heart failure.[54] As such, for the health care provider, they are the important outcome measures for assessing the effects of exercise training on patients with heart failure. Only one study addressed these outcome measures.[33]

Some studies assessed the patient's quality of life and well-being, but the suitability of the quality-of-life measurements used has sometimes been questionable.[55] For example, the use of the Standard Gamble Test[56,57] is not recommended for assessing interventions for chronic conditions, particularly heart failure. Research has found that this measurement is insufficient in terms of construct validity and can produce misleading conclusions about the effect of treatments on health status. Thus, some of the outcomes obtained may be misleading. Greater consideration needs to be given, both to the selection of an appropriate quality of life measure and the timing of its administration, to gain an accurate account of improvements in quality of life.

Although favourable rates of completion and compliance are reported it is possible that this is related to the relatively brief duration of the studies. Other factors, such as the choice of setting and the use of convenience samples, may also have impacted the figures cited.

The research to date does not provide conclusive guidance regarding the applicability of exercise training for the general population of heart failure patients. This work serves to re-emphasise a problem highlighted previously, namely the need for more trials in typical patients.[58] Larger, long-term trials are required which represent all heart failure patient groups in terms of age, sex, common co-morbidities, and location (i.e. hospital versus community-based) to clarify whether exercise has the desired physical and life-enhancing effects, and thus should be widely recommended. In addition, patients' acceptance of, and willingness to, adopt exercise programmes on a long-term basis needs to be explored. Comprehensive long-term studies should include health care utilisation, mortality, quality of life, and cost-effectiveness as outcome measures.

The trials included in this review perhaps reveal the difficulties of recruitment. A different approach to such trials might alleviate such problems; for example, the use of multi-centre trials, following a common research protocol with pooled findings into a central database for analysis.

To conclude, there remains a lack of information concerning two important points to practitioners:

1. whether particular groups of heart failure patients should be encouraged to adopt a programme of exercise; and
2. if exercise training is deemed appropriate, what should be the nature, duration, frequency and intensity of the programme.

Health care providers need validated research findings, which will enable the prescription of appropriate exercise regimens for patients with heart failure. At present there remains a paucity of high-quality evidence to support the further development of guidelines for health care providers or patients regarding the subject of exercise and heart failure. For all grades of heart failure, the goals of therapy are to decrease symptoms, decrease morbidity, and prolong life. Although the initial work is extremely promising, whether exercise can help achieve these aims remains uncertain.

References

1. Grady KL. Quality of life in patients with chronic heart failure. *Crit Care Nurse Clin North Am* 1993; **5:** 661-670.
2. McMurray J, Dargie HJ. Trends in hospitalisation for chronic heart failure in the United Kingdom. *Eur Heart J* 1992; **13 suppl:** 350.
3. McMurray J, Hart W, Rhodes G. An evaluation of the cost of heart failure to the National Health Service in the UK. *Br Med J Econ* 1993; **6:** 99-110.
4. Konstam M, Dracup K, Baker D, *et al. Heart failure: evaluation and care of patients with left-ventricular systolic dysfunction. Clinical Practice Guideline No. 11.* [AHCPR Publication No. 94-0612.]. Agency for Health Care Policy and Research, Public Health

Service, U.S. Department of Health and Human Services, Rockville, MD, June 1994.
5. Guidelines for the evaluation and management of heart failure. Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Evaluation and Management of Heart Failure. *Circulation* 1995; **92(9):** 2764-2784.
6. Guidelines for the diagnosis of heart failure. The Task Force on Heart Failure of the European Society of Cardiology. *Eur Heart J* 1995; **16(6):** 741-751.
7. The Task Force of the Working Group on Heart Failure of the European Society of Cardiology. The treatment of heart failure. *Eur Heart J* 1997; **18 (5):** 736-753.
8. The National Heart Foundation of New Zealand, Cardiac Society of Australia and New Zealand and the Royal New Zealand College of General Practitioners Working Party. New Zealand guidelines for the management of chronic heart failure. *N Z Med J* 1997; **110:** 99-107.
9. Canadian Cardiovascular Society. Diagnosis and management of heart failure. Canadian Cardiovascular Society — Consensus Development Conference Guidelines. *Can J Card* 1994; **10:** 613-631 and 635-654.
10. Dracup K, Baker DW, Dunbar SB, *et al*. Management of heart failure. II. Counseling, education and lifestyle modifications. *JAMA* 1994; **272:** 1442-1446.
11. Sullivan M. Exercise training in heart failure: an intervention whose time has come. *J Card Fail* 1997; **3(1):** 13-14.
12. NHS Centre for Reviews and Dissemination. *Report Number 4.* York: University of York, January 1996.
13. Meyer K, Samek L, Schwaibold M, *et al*. Physical responses to different modes of interval exercise in patients with chronic heart failure — application to exercise training. *Eur Heart J* 1996; **17:** 1040-1047.
14. Wielenga RP, Erdman RAM, Huisveld IA, *et al*. Effect of exercise training on quality of life in patients with chronic heart failure. *J Psysom Res* 1998; **45(5):** 459-464.
15. Wielenga RP, Huisveld IA, Bol E, *et al*. Exercise training in elderly patients with chronic heart failure. *Coronary Artery Dis* 1998; **9:** 765-770.
16. Coats AJS, Adamopoulos S, Meyer TE, Conway J, Sleight P. Effects of physical training in chronic heart failure. *Lancet* 1990; **335:** 63-66.
17. Hambrecht R, Niebauer J, Fiehn E, *et al*. Physical training in patients with stable chronic heart failure: effects on cardiorespiratory fitness and ultrastructural abnormalities of leg muscles. *J Am Coll Cardiol* 1995; **25(6):** 1239-1249.
18. Jadad AR, Moore RA, Carroll D, *et al*. Assessing the quality of reports on randomized clinical trials: is blinding necessary? *Control Clin Trials* 1996; **17:** 1-12.
19. Jette M, Heller R Landry F, Blumchen G. Randomized 4-week exercise program in patients with impaired left ventricular function. *Circulation* 1991; **84(4):** 1561-1567.
20. Davey P, Meyer T, Coats A, *et al*. Ventilation in chronic heart failure: effects of physical training. *Br Heart J* 1992; **68:** 473-477.
21. Hambrecht R, Gielen S, Linke A, *et al*. Effects of exercise training on left ventricular function and peripheral resistance in patients with chronic heart failure: A randomized trial. *JAMA* 2000; **283(23):** 3095-3101.
22. Kiilavuori K, Sovijarvi A, Naveri H, *et al*. Effect of physical training on exercise capacity and gas exchange in patients with chronic heart failure. *Chest* 1996; **110(4):** 985-991.
23. Gordon A, Tyni-Lenne PR, Persson H, *et al*. Markedly improved skeletal function with local muscle training in patients with chronic heart failure. *Clin Cardiol* 1996; **19:** 568-574.
24. Keteyian SJ, Levine AB, Brawner CA, *et al*. Exercise training in patients with heart failure. A randomized controlled trial. *Ann Intern Med* 1996; **124(12):** 1051-1057.
25. Meyer K, Schwaibold M, Westbrook S, *et al*. Effects of short-term exercise training and activity restriction on functional capacity in patients with severe chronic congestive heart failure. *Am J Cardiol* 1996; **78(9):** 1017-1022.
26. Coats AJ, Adamopoulos S, Radaelli A, *et al*. Controlled trial of physical training in chronic heart failure. Exercise performance, hemodynamics, ventilation, and automatic function. *Circulation* 1992; **85(6):** 2119-2131.
27. Koch M, Douard H, Broustet JP. The benefit of graded physical exercise in chronic heart failure. *Chest* 1992; **101(5 suppl):** 231S-235S.
28. Tyni-Lenne PR, Gordon AA, Sylven C. Improved quality of life in chronic heart failure patients following local endurance training with leg muscles. *J Card Fail* 1996; **2(2):** 111-117.
29. Cider A, Tygesson H, Hedberg M, *et al*. Peripheral muscle training in patients with clinical signs of heart failure. *Scand J Rehabil Med* 1997; **29:** 121-127.
30. Willenheimer R, Erhardt L, Cline C, *et al*. Exercise training in heart failure improves quality of life and exercise capacity. *Eur Heart J* 1998; **19(5):** 774-781.
31. Johnson PH, Cowley AJ, Kinnear WJM. A randomized controlled trial of inspiratory muscle training in stable chronic heart failure. *Eur Heart J* 1998; **19:** 1249-1253.
32. Wielenga RP, Huisveld IA, Bol E, *et al*. Safety and effects of physical training in chronic heart failure. *Eur Heart J* 1999; **20:** 872-879,
33. Belardinelli R, Georgiou D, Cianci G, Purcaro A. Randomized, controlled trial of long-term moderate exercise training in chronic heart failure: effects on functional capacity, quality of life, and clinical outcome. *Circulation* 1999; **99:** 1173-1182.
34. Conn EH, Williams RS, Wallace AG. Exercise responses before and after physical conditioning in patients with severely depressed left ventricular function. *Am J Cardiol* 1982; **49(2):** 296-300.
35. Scalvini S, Marangoni S, Volterrani M, *et al*. Physical rehabilitation in coronary patients who have suffered from episodes of cardiac failure. *Cardiology* 1992; **80:** 417-423.
36. Belardinelli R, Georgiou D, Scocco V, *et al*. Low intensity exercise training in patients with chronic heart failure. *J Am Coll Cardiol* 1995; **26(4):** 975-982.
37. Tyni-Lenne PR, Gordon A, Europe E, *et al*. 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(1):** 9-17.
38. Kavanagh T, Myers MG, Baigrie RS, *et al*. Quality of life and cardiorespiratory function in chronic heart failure: effects of 12 months' aerobic training. *Heart* 1996; **76(1):** 42-49.
39. Shephard RJ, Kavanagh T, Mertens DJ. On the prediction of physiological and psychological responses to aerobic training in patients with congestive heart failure. *J Cardiopulm Rehabil* 1998; **18(1):** 45-51.
40. Tyni-Lenne PR, Gordon A, Jansson E, *et al*. Skeletal muscle endurance training improves peripheral oxidative capacity, exercise tolerance, and health-related quality of life in women with chronic congestive heart failure secondary to either ischemic cardiomyopathy or idiopathic dilated cardiomyopathy. *Am J Cardiol* 1997; **80(8):** 1025-1029.
41. Sullivan MJ. Higginbotham MB, Cobb FR. Exercise training in patients with severe left ventricular dysfunction. *Circulation* 1988; **78:** 506-515.
42. European Heart Failure Training Group. Experience from controlled trials of physical training in chronic heart failure. *Eur Heart J* 1998; **19:** 466-475.
43. Tyni-Lenne R, Gordon A, Jensen-Urstad M, *et al*. Aerobic training involving a minor muscle mass shows greater efficiency than training involving a major muscle mass in chronic heart failure patients. *J Card Fail* 1999; **5(4):** 300-307.
44. Maiorana A, O'Driscoll G, Cheetham C, *et al*. Combined aerobic and resistance exercise training improves functional capacity and strength in CHF. *J Appl Physiol* 2000: **88(5):** 1565-70.
45. Delagardelle C, Feiereisen P, Krecke R, *et al*. Objective effects of a 6 months' endurance and strength training program in outpatients with congestive heart failure. *Med Sci Sports Ex* 1999; **31(8):** 1102-1107.
46. Oka RK, De Marco T, Haskell WL, *et al*. Impact of a home-based walking and resistance training program on quality of life in patients with heart failure. *Am J Cardiol* 2000; **85(3):** 365-369.
47. Quittan M, Sturm B, Wiesinger G, *et al*. Quality of life in patients with chronic heart failure: A randomized controlled trial of changes induced by a regular exercise program. *Scand J Rehab Med* 1999; **31:** 223-228.
48. Owen A, Croucher L. Effect of an exercise programme for elderly patients with heart failure. *Eur J Heart Fail* 2000; **2(1):** 65-70.
49. Taylor A. Physiological response to a short period of exercise training in patients with chronic heart failure. *Physiother Res Int* 1999; **4(4):** 237-249.
50. Kannel WB Epidemiological aspects of heart failure. *Cardiol Clin* 1989; **7:** 1.
51. Schocken DD, Arriata MI, Laever PE, Ross EA. Prevalence and mortality rate of congestive heart failure in the United States. *J Am Coll Cardiol* 1992; **20:** 301-306.
52. Ho KKL, Pinsky JL, Kannel WB, Levy D. The epidemiology of heart failure: the Framingham study. *J Am Coll Cardiol* 1993; **22:** 6A-13A.
53. McDonagh TA, Morrison CE, Lawrence A, *et al*. Symptomatic and asymptomatic left ventricular systolic dysfunction. *Lancet* 1997; **350:** 829-833.
54. Dargie HJ, McMurray JV, McDonagh TA. Heart failure — implications of the true size of the problem. *J Int Med* 1996; **239:** 309-315.

55. Berry C, McMurray JV. A review of quality-of-life evaluations in patients with congestive heart failure. *Pharmacoeconomics* 1999; **16(3):** 247-271.
56. Guyatt GH, King DR, Feeny DH, *et al*. Generic and specific measurement of health-related quality of life in a clinical trial of respiratory rehabilitation. *J Clin Epidemiol* 1999; **52(3):** 187-192.
57. Goossen ME, Vlaeyen JW, Rutten van Molken MP, *et al*. Patient utilities in chronic musculoskeletal pain: how useful in the standard gamble method? *Pain* 1999; **80(1-2):** 365-375.
58. McMurray J. Heart failure: we need more trials in typical patients. *Eur Heart J* 2000; **21:** 699-700, doi:10.1053/euhj.1999.1974

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