Effects of cardiac rehabilitation on functional capacity and quality of life in patients with normal and impaired left ventricular function
Nieuwland, Wybe
Chapter 8
Long term effects of a 6-week cardiac rehabilitation on exercise capacity, quality of life, and life-style; comparison of high versus low frequency exercise training of patients with coronary artery disease.

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ABSTRACT

Background.
We recently reported on short-term effects of a 6-week multi-disciplinary cardiac rehabilitation (CR) program, comparing high-frequency (HF) with low-frequency (LF) exercise training, and demonstrated a significantly higher improvement on ventilatory anaerobic threshold (VAT) and some parameters on health related quality of life (QoL) during HF training. Another important issue should be, whether these short-term effects on VAT, QoL, or life-style are maintained on long-term. These issues are of particular concern from an (cost-)effectiveness standpoint.

Patients and methods.
One hundred and thirty patients (male 114, female 16; age 52 ± 9) with coronary artery disease (80% after a myocardial infarction) were randomized to HF or LF exercise training (6 weeks, respectively, 10 or 2 exercise sessions a week) during a phase 2 multidisciplinary CR-program. Follow-up contained a maintenance stage (6 weeks 1 exercise session a week for both programs) and thereafter evaluations at 6 and 15 months after inclusion. Peak oxygen consumption (VO₂) and VAT were measured during symptom-limited bicycle exercise tests. QoL was determined by questionnaires and lifestyle risk factors for coronary artery disease (i.e. physical inactivity, compliance to diet, smoking) were obtained by interview.

Results.
After 6 and 15 months, peak VO₂ was still significantly higher than at baseline in both groups despite a gradually decrease (6 and 15 months resp.: HF +7% and +6%; LF +10% and 7%; all significant). Although the increase of VAT remained remarkably higher in the HF-group, this difference was not significant (6 and 15 months resp.: HF +22% and +27%; LF +7% and 2%; resp. p<0.05, p<0.05, p<0.05, p=ns). Improvements in QoL were stable along the follow-up in both groups. However, no significant differences between both groups were observed anymore. The effects on life-style were especially observed right after CR, but both compliance to diet and physical activities decreased gradually during a year follow-up. Physical activities increased significantly in both groups both on short- and long-term (after 6 and 15 months, resp. HF +770 kcal/week and +573; LF +378 and +265; all p<0.05). Although the improvement was most pronounced in the HF-group, the difference between both groups was not significant. The initial compliance to dietary advises was high in both groups, as reflected by especially a decrease of total energy intake compared with baseline (at 6 months HF -2363 kJ/day and LF-1633, both p<0.005). However at follow-up this effect on total energy intake decreased in both groups, especially in the LF-group (at 15 months versus baseline HF -1595 and LF -805, resp. p<0.005, p=0.064).

Conclusion.
Long-term effects of HF- and LF-programs during CR are comparable with respect to exercise capacity, QoL, and lifestyle. Since the HF-program is superior on the short
term with respect to endurance exercise capacity and QoL, this might be preferred when a quick recovery and early increase of endurance exercise capacity is required. Short-term effects on lifestyle (physical activities and diet) decrease gradually during one year follow-up, but tended to be preserved better after a HF-program.

INTRODUCTION

The value of exercise training during cardiac rehabilitation (CR) is well documented and generally accepted\(^1,2\). Beneficial effects on exercise capacity and health related Quality of Life (QoL) were observed\(^3,4,5\). Also effects on (cardiac) mortality and morbidity were demonstrated\(^2,6,7\). Although the contribution of multi-disciplinary approach and other treatment modalities is recognized nowadays\(^8,9\), exercise training is still the mainstay of most CR programs. However, different modalities of exercise training are hardly compared in randomized clinical trials. Especially frequency of exercise training was never studied. Recently we compared high- with low-frequency exercise training (respectively HF and LF) during CR and reported the beneficial short-term effects of HF exercise training on endurance exercise capacity and health related QoL\(^10,11\).

Short-term effects of CR are important with respect to restoration of normal daily functioning and should be studied to evaluate effectiveness of training programs. For this purpose and the purpose of secondary prevention, preservation of these beneficial effects is also important. This issue, however, has hardly been studied before. Especially the studies of Hedbäck have suggested beneficial effects on cardiac mortality and morbidity at 5- and 10-years follow-up in a non-randomized study\(^12,13\).

Therefore, we recently reported the short-term results of a clinical controlled trial, which compared the effects of either HF or LF exercise training, during a 6-week multi-disciplinary, phase II (outpatient) CR program. Short-term effects of the HF program were superior on improvement of endurance exercise capacity and QoL (10, 11). The present study evaluated, whether these short-term effects could be sustained with a maintenance program and during a year follow-up. Outcome of the CR-program was tested on exercise capacity, QoL, life-style related to coronary risk factors and Left Ventricular (LV) function after the program and during a year follow-up.

METHODS

Study-design.

Patients, who had been hospitalised with manifestations of (documented) coronary artery disease (i.e. myocardial infarction, angina pectoris, coronary surgery, or coronary angioplasty), were referred to our CR centre. They were eligible for the study, if their age was between 30 and 70 years. Exclusion criteria were unstable angina, clinically unstable heart failure, unstable arrhythmias, contraindications for exercise training, other exercise limiting concurrent condition (e.g. chronic obstructive pulmonary
disease, skeletal or muscular disorders), or a psychosocial indication for inpatient CR. Patients were randomised either to HF or LF exercise training during a 6 weeks outpatient (phase II) CR program. Follow-up after the rehabilitation stage was identical in both groups and consisted of a 6 weeks maintenance stage and of an outpatient clinic visit at 6 and 15 months after inclusion (figure 1). Exercise capacity and QoL were recorded at baseline (T1), after 6 weeks (end of rehabilitation stage) (T2), 12 weeks (end of maintenance stage) (T3), and 6 and 15 months after inclusion (T4 and T5). In addition, we recorded at T1, T3 and T5 also risk factors for coronary artery disease and resting LV-function. LV-function was evaluated by echocardiography (Vingmed CFM 800; Horten, Norway); in addition to diameters obtained in standardised positions also LV ejection fraction (LVEF) and Wall Motion Score Index (WMSI) was measured. Randomisation was executed externally after assessment of baseline data and obtaining written informed consent. The study-protocol was approved by the institutional review board and was in accordance with the Helsinki Declaration.

Outline of the training programs.

The frequency of exercise training during the 6-week rehabilitation stage was the only difference between both programs. The HF program consisted of 2 training-sessions each day, 5 days a week, while the LF program consisted of 1 training-session a day, twice a week. Each training-session consisted of cycling on an ergometer (6 minutes warm-up, 20 minutes endurance training with heart rate maintained on 60 to 70% of Heart Rate Reserve, 4 minutes cool-down) and 45 to 60 minutes sports-

![Figure 1. Study design.](image-url)
activities (swimming, walking or jogging, ballsports, callisthenics). In addition all patients joined an education program and participated in relaxation therapy and breathing technique instructions for once a week. Spouses were also invited to join two exercise-sessions and an education program. A dietician, social worker and/or psychologist individually counselled patients. Following the rehabilitation stage, all patients participated in the same maintenance stage, in which they attended one training session a week and were encouraged to start regular physical activities by themselves.

**Exercise testing.**

Exercise capacity was measured during graded symptom-limited exercise tests on an electro-magnetically braked cycle ergometer (Lode Excalibur, Netherlands) with respiratory gas exchange measurement (Oxycon Champion, Jaeger, Netherlands) as previously described in detail\(^\text{15}\). All patients were familiarised to the exercise testing protocol 1-3 days before baseline exercise test by a preliminary exercise test. The protocol consisted of a three-minute warm-up period at a workload of 20 Watt. The next stage, the workload was increased to 50 Watt and then by 10 Watt every subsequent minute. Patients were instructed to maintain a speed of 60 to 70 rotations per minute. Blood pressure was measured pre-exercise, every three minutes during exercise and post-exercise. A capillary blood-sample was obtained within 45 seconds after peak exercise to measure blood-lactate concentration. At \(t_2-t_5\) we obtained also a blood-sample at a sub-maximal exercise stage (i.e. the exercise stage comparable with the stage of peak workload at \(t_1\)). At this sub-maximal workload we also measured heart rate, blood pressure, \(O_2\) uptake (\(VO_2\)), and Respiratory Exchange Ratio (RER). Respired gases were analysed for volumes, \(F(raction)\) \(O_2\) and \(FCO_2\) breath by breath. Peak \(O_2\) consumption (\(VO_2\)) was defined as the mean \(VO_2\) of the last minute of the exercise test. VAT was determined using the RER = 1 method\(^\text{16}\) and was reported in workload (Watt). Exercise tests were symptom-limited and were encouraged to perform maximally to symptoms of dyspnea or general fatigue to a level of perceived exertion of 19 to 20 according the Borg scale\(^\text{17}\). The reason for termination of the test was in none of the patients angina, ventricular arrhythmias, decrease of systolic blood pressure, or severe changes of the ECG (ST-depression > 4 mm or bundle branch block).

**QoL assessment.**

Subjective improvement on health was assessed with various questionnaires. We used the RAND-36, which is a Dutch version of the MOS SF-36 (Medical Outcomes Survey 36-item Short Form health domains) and used the sub-scales subjective physical functioning, mental health, vitality\(^\text{18,19}\). In addition, we also used the General Health Questionnaire (GHQ)\(^\text{20}\), the Heart Patient Psychological Questionnaire (HPPQ)\(^\text{21}\), the Cardiac Self-efficacy Questionnaire assessing controlling symptoms (SE-CS) and maintaining function (SE-MF)\(^\text{22}\), and the Linear Analogue Self-Assessment Scale (LASA)\(^\text{10}\). All questionnaires were obtained at all five moments except the HPPQ, which was obtained at \(t_1\), \(t_3\), and \(t_5\).
Risk factors.

Physical activities were determined at \( t_1 \), \( t_3 \) and \( t_5 \) with the Minnesota Leisure Time Physical Activity Questionnaire\textsuperscript{23}. At \( t_1 \) we evaluated the level of physical activities during the period of one year before the last cardiac event. At \( t_3 \) and \( t_5 \) respectively the past 6 weeks and past 12 months. Total energy expenditure was estimated in kilocalories a week by the product of frequency and duration of physical activities (obtained with the Minnesota Questionnaire) and intensity code\textsuperscript{24}. A dietician obtained food habits during a structured interview (‘VET-expres’)\textsuperscript{25} and the mean fat and caloric intake was calculated.

Statistical analysis.

Statistics were obtained using SPSS (PC\textsuperscript{+}, version 5.01 1992). Differences between groups (HF versus LF and improvement versus no improvement) and the changes during the program and follow-up compared with baseline were analysed using unpaired t-test. Differences in efficacy between both programs were analysed with MANOVA for repeated measures. Significance was expected to occur when (two-tailed) p-values were below 0.05. Group data for each variable are expressed as mean value ± SD.

<table>
<thead>
<tr>
<th></th>
<th>High-frequency (n=63)</th>
<th>Low-frequency (n=67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>52 ± 9</td>
<td>53 ± 9</td>
</tr>
<tr>
<td>Gender</td>
<td>Male/female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>52/11 (83/17%)</td>
<td>62/5 (93/7%)</td>
</tr>
<tr>
<td>Length</td>
<td>175.4 ± 8.2</td>
<td>177.2 ± 7.5</td>
</tr>
<tr>
<td>Weight</td>
<td>80.1 ± 11.0</td>
<td>79.2 ± 10.9</td>
</tr>
<tr>
<td>Last cardiac event</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>47 (75%)</td>
<td>51 (76%)</td>
</tr>
<tr>
<td>CABG</td>
<td>6 (9%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>PTCA</td>
<td>6 (9%)</td>
<td>5 (8%)</td>
</tr>
<tr>
<td>Angina</td>
<td>4 (7%)</td>
<td>9 (13%)</td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta-blocker</td>
<td>49 (78%)</td>
<td>55 (82%)</td>
</tr>
<tr>
<td>Calcium-antagonist</td>
<td>13 (21%)</td>
<td>19 (28%)</td>
</tr>
<tr>
<td>Nitrate</td>
<td>13 (21%)</td>
<td>18 (27%)</td>
</tr>
<tr>
<td>ACE-inhibitor</td>
<td>19 (30%)</td>
<td>17 (25%)</td>
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<tr>
<td>Diuretics</td>
<td>12 (19%)</td>
<td>13 (19%)</td>
</tr>
<tr>
<td>Digitalis</td>
<td>4 (6%)</td>
<td>5 (8%)</td>
</tr>
<tr>
<td>LVEF</td>
<td>0.48 ± 0.11</td>
<td>0.46 ± 0.10</td>
</tr>
<tr>
<td>Wall Motion Score Index</td>
<td>1.35 ± 0.36</td>
<td>1.31 ± 0.30</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>NYHA I/II/III 47/15/1 (75/23/2%)</td>
<td>50/17/0 (75/25/0%)</td>
</tr>
<tr>
<td>Angina</td>
<td>NYHA I/II 58/5 (92/8%)</td>
<td>53/14 (79/21%)</td>
</tr>
</tbody>
</table>

Table 1. Baseline characteristics

\( \text{MI} = \) myocardial infarction; \( \text{CABG} = \) coronary surgery; \( \text{PTCA} = \) coronary angioplasty; \( \text{NYHA} = \) functional classification according to New York Heart Association; \( \text{LVEF} = \) left ventricular ejection fraction.
RESULTS

Overall population.

One hundred and thirty patients were randomised of a total of 186 patients who met in- and exclusion criteria. Reasons for non-randomisation were: no reliable measurement of baseline parameters (i.e. exercise tests, echocardiography, or questionnaires) (11 patients), and refusal of participation in one or another program. There were no major differences between both groups in baseline characteristics, including number and localisation of myocardial infarctions and resting LV-function (table 1). We observed only differences of marginal significance in sub-scales of the RAND-36 (mental health, vitality, social functioning) at baseline (table 2). During the rehabilitation stage 5 patients dropped-out (HF 1 and LF 4; p = n.s.). In 1 patient (HF) the drop-out was caused by the occurrence of unstable angina pectoris, treated by coronary bypass surgery); 4 patients (LF) stopped attending exercise sessions due to lack of motivation (3x) or to resumption of work (1x). Two patients discontinued the program during the maintenance stage because of personal problems (HF and LF both 1). We lost track of 10 patients (HF and LF respectively 3 and 7) during follow up for several reasons [i.e. refusal for further participation (LF 2), severe depressive syndrome (LF 1), other interventions (cardiomyoplasty 1, angioplasty 1; both LF), cerebrovascular accident (HF 2, one died), pneumonia during t4 (HF 1), or we were unable to contact them (LF 2)].

Exercise capacity.

Exercise capacity improved highly significantly during the rehabilitation stage of both programs (table 2). The increase of VAT was significantly greater in the HF-program, compared with LF. In contrast, the increase of peak VO2 was comparable in both groups (both +11%). During the maintenance stage exercise capacity stabilised in the HF-group, while a slight additional increase was observed in the LF-group (table 2; figure 2 and 3). As a consequence, no differences in efficacy between both programs were observed anymore by the end of the maintenance stage. At t4 exercise capacity decreased significantly in both groups, but exercise capacity remained greater at t4 and t5 than at baseline (p<0.001). However, the VAT returned to baseline at t5 in the LF-group, while the VAT at t5 was still 17% above baseline in the HF-group (p<0.05) (figure 3).

LV-function.

At baseline mean LV-function was in both groups comparable and slightly decreased (HF versus LF respectively: LVEF 0.48 and 0.45; WMSI 1.29 and 1.29). LVEF slightly increased at t3 and t5 in both groups to respectively 0.49 and 0.48(table 2). This increase proved to be significant only in the LF-group. However, no significant differences were observed between both groups. The improved LV-function was also reflected in the improved WMSI (borderline) in the LF-group (p=n.s.). Remarkably, the WMSI increased in the HF-group. This increase was small but at t5 significant, compared with t1 (p<0.05).
### Table 2: Parameters of exercise capacity, left ventricular function, and health-related quality of life at baseline, after rehabilitation and at follow-up.

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>T1</th>
<th></th>
<th>T2</th>
<th></th>
<th>T3</th>
<th></th>
<th>T4</th>
<th></th>
<th>T5</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>HF</td>
<td>LF</td>
<td>HF</td>
<td>LF</td>
<td>HF</td>
<td>LF</td>
<td>HF</td>
<td>LF</td>
<td>HF</td>
<td>LF</td>
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<tr>
<td>Physiologic</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Peak workload</td>
<td>138 ± 45</td>
<td>153 ± 37</td>
<td>161 ± 47'' , #</td>
<td>173 ± 42</td>
<td>159 ± 49''</td>
<td>179 ± 39''</td>
<td>154 ± 49''</td>
<td>174 ± 41''</td>
<td>155 ± 47''</td>
<td>170 ± 39''</td>
</tr>
<tr>
<td>Peak VO2</td>
<td>22.6 ± 6.9</td>
<td>24.1 ± 5.1</td>
<td>25.1 ± 7.1</td>
<td>24.7 ± 6.4</td>
<td>24.9 ± 6.7''</td>
<td>27.9 ± 4.6''</td>
<td>24.2 ± 6.8''</td>
<td>26.5 ± 5.9''</td>
<td>24.0 ± 6.5</td>
<td>25.8 ± 5.6''</td>
</tr>
<tr>
<td>Peak RER</td>
<td>1.12 ± 0.08</td>
<td>1.11 ± 0.06</td>
<td>1.11 ± 0.07</td>
<td>1.12 ± 0.08</td>
<td>1.11 ± 0.07</td>
<td>1.12 ± 0.06</td>
<td>1.14 ± 0.08</td>
<td>1.13 ± 0.07</td>
<td>1.12 ± 0.07</td>
<td>1.13 ± 0.06</td>
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<tr>
<td>Peak minute ventilation</td>
<td>69 ± 22</td>
<td>74 ± 16</td>
<td>77 ± 21''</td>
<td>86 ± 20''</td>
<td>76 ± 20''</td>
<td>90 ± 20''</td>
<td>75 ± 21''</td>
<td>86 ± 15''</td>
<td>78 ± 22''</td>
<td>86 ± 17''</td>
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<tr>
<td>HR peak</td>
<td>132 ± 22</td>
<td>138 ± 23</td>
<td>134 ± 19</td>
<td>142 ± 20'</td>
<td>137 ± 22</td>
<td>144 ± 19'</td>
<td>137 ± 18'</td>
<td>146 ± 22'</td>
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<td>143 ± 23</td>
</tr>
<tr>
<td>RR sys peak</td>
<td>119 ± 20</td>
<td>130 ± 21</td>
<td>125 ± 19</td>
<td>121 ± 22</td>
<td>125 ± 14</td>
<td>134 ± 20</td>
<td>130 ± 19</td>
<td>133 ± 22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR dia peak</td>
<td>83 ± 11</td>
<td>83 ± 13</td>
<td>85 ± 13</td>
<td>84 ± 12</td>
<td>82 ± 16</td>
<td>84 ± 13</td>
<td>87 ± 13</td>
<td>83 ± 14</td>
<td>88 ± 15</td>
<td>83 ± 13</td>
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<tr>
<td>VAT</td>
<td>95 ± 35</td>
<td>108 ± 36</td>
<td>125 ± 45'' , #</td>
<td>123 ± 41''</td>
<td>114 ± 43''</td>
<td>126 ± 36''</td>
<td>106 ± 39''</td>
<td>116 ± 38''</td>
<td>111 ± 37''</td>
<td>110 ± 40</td>
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<tr>
<td>VO2</td>
<td>16.6 ± 4.8</td>
<td>17.9 ± 4.3</td>
<td>20.0 ± 6.2'' , #</td>
<td>19.9 ± 5.1''</td>
<td>18.6 ± 5.6'</td>
<td>19.8 ± 4.2''</td>
<td>16.9 ± 4.4</td>
<td>18.3 ± 5.6</td>
<td>17.8 ± 4.7</td>
<td>17.8 ± 5.0</td>
</tr>
</tbody>
</table>

**LV-function**

| LVEF fraction   | 0.48 ± 0.10 | 0.45 ± 0.09 | 0.49 ± 0.11 | 0.47 ± 0.09 | 0.49 ± 0.11 | 0.49 ± 0.11 | 0.49 ± 0.11 | 0.48 ± 0.09 |
| WMSI            | 1.29 ± 0.29 | 1.29 ± 0.31 | 1.32 ± 0.33 | 1.29 ± 0.32 | 1.37 ± 0.34 | 1.26 ± 0.33 |

**Quality of Life**

| GHQ             | 17.4 ± 7.5 | 15.3 ± 5.9 | 9.5 ± 5.2'' | 10.9 ± 4.4'' | 11.5 ± 5.6'' | 10.7 ± 4.7'' | 10.9 ± 4.2'' | 11.1 ± 4.7'' | 10.6 ± 4.6'' | 10.2 ± 3.8'' |
| Subjective physical functioning | 69.5 ± 21.4 | 78.4 ± 17.8 | 79.6 ± 19.4'' | 83.2 ± 17.0 | 79.7 ± 22.5'' | 84.4 ± 14.7'' | 81.6 ± 21.1'' | 82.8 ± 17.0 | 76.5 ± 23.3 | 86.8 ± 15.4'' |
| Mental health   | 56.8 ± 23.2 | 68.3 ± 15.7 | 68.8 ± 19.3'' | 68.7 ± 16.0 | 68.6 ± 20.3'' | 71.7 ± 18.5 | 70.3 ± 17.6 | 71.8 ± 16.7 | 71.5 ± 17.8'' | 74.3 ± 16.3'' |
| Vitality        | 50.7 ± 21.4 | 58.9 ± 18.9 | 59.2 ± 16.1'' | 63.8 ± 17.9 | 61.2 ± 18.2'' | 65.7 ± 19.7 | 61.1 ± 18.0 | 64.0 ± 17.8 | 62.3 ± 17.5'' | 67.7 ± 18.9'' |
| Self-efficacy   | 23.5 ± 3.7 | 23.9 ± 2.7 | 24.1 ± 3.0 | 25.0 ± 2.5 | 24.5 ± 2.8 | 25.1 ± 3.1 | 24.9 ± 3.8 | 24.6 ± 3.1 | 24.8 ± 3.1 | 24.9 ± 3.1 |
| Overall (LASA)  | 53.1 ± 21.1 | 62.4 ± 18.9 | 62.4 ± 17.0' | 67.3 ± 17.2 | 61.6 ± 20.1'' | 66.6 ± 15.1 | 65.7 ± 16.6 | 61.6 ± 21.6 | 66.8 ± 17.1'' | 72.0 ± 17.4'' |

* Significant change versus baseline (t1); p < 0.05; ** = significant change versus baseline (t1); p < 0.005; *= significant difference between HF and LF; p < 0.05* = p<0.05, ** = p<0.005.

Abbreviations: Wmax = peak workload; HR peak = heart rate at peak exercise; RR sys peak = systolic blood pressure at peak exercise; RR sys sub = systolic blood pressure at submaximal exercise; RR dia peak = diastolic blood pressure at peak exercise; RR dia sub = diastolic blood pressure at submaximal exercise; RER peak = respiratory exchange ratio at peak exercise; Clactate peak = serum lactate concentration at peak exercise; VAT = ventilatory anaerobic threshold. LVEF = left ventricular ejection fraction; WMSI = wall motion score index. GHQ = general health questionnaire assessing psychological distress, LASA = linear analogue self-assessment scale. For description of the different questionnaires used, see text.
QoL.

QoL improved during the rehabilitation stage of both programs at most parameters. This increase was most pronounced in the HF-group. The significant program effect was demonstrated in mental health (RAND-36) and distress (GHQ). This emotional recovery stabilised during the maintenance stage and also during the follow-up. At t5 the LF-group was significantly better in subjective physical functioning (RAND-36) and overall QoL (LASA). Remarkable was the increase of self-efficacy. This increase was especially demonstrated in the LF-group during the rehabilitation stage (difference with HF only marginally significant). This difference disappeared gradually due to a gradual further improvement in HF-group, while it stabilised in the LF-group.

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**Fig. 2.** Peak VO2 (ml/kg/min)

*HF = high frequency program, LF = low-frequency program. Evaluation moments at start and end (= 6 weeks) of cardiac rehabilitation, at end of maintenance stage (= 12 weeks), and two outpatient visits respectively 6 and 15 months after start.*

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**Fig. 3.** Ventilatory anaerobic threshold (Watt).

*HF = high frequency program, LF = low-frequency program. Evaluation moments at start and end (= 6 weeks) of cardiac rehabilitation, at end of maintenance stage (= 12 weeks), and two outpatient visits respectively 6 and 15 months after start.*
Risk factors.

Compliance to diet was high during rehabilitation. After the maintenance stage the intake of energy, cholesterol, total fat, and saturated fat decreased significantly in both groups (table 3). However, energy-intake gradually increased during follow-up especially in the LF-group and was comparable with t1 in the LF-group at t5, while it was still significantly lower in the HF-group.

Physical activities increased significantly in both groups at t3 (table 3). This increase was most pronounced in the HF-group (HF and LF resp.: +770 kcal/week and +3788, both p<0.05 versus baseline, however no program x time interaction effect) (figure 4). Physical activities fell back in both groups at t5, but still patients of the HF-group tended to be physically more active (HF and LF resp.: +573 and +265; both p<0.05 versus baseline, no program x time interaction effect).

In 72 patients smoking history could be recorded. A remarkable number had a smoking history (57; 79%). Most smokers quitted smoking while they were still in-hospital recovering from myocardial infarction (n=47). Only 4 patients quitted smoking during cardiac rehabilitation and no one resumed smoking. During follow up 5 patients resumed smoking cigarettes.

![Fig.4](image-url). Physical activity energy expenditure in kilocalory a week increased significantly both after the maintenance stage and at follow up after 1 year. Although the improvement tended to be more pronounced in the high-frequency group, no significant program effect was observed. (HF = high-frequency group, LF = low-frequency group)
<table>
<thead>
<tr>
<th></th>
<th>T1 HF</th>
<th>LF</th>
<th>T3 HF</th>
<th>LF</th>
<th>T5 HF</th>
<th>LF</th>
<th>n</th>
<th>HF</th>
<th>LF</th>
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<tbody>
<tr>
<td>Physical activities kcal/week</td>
<td>924 ± 1224</td>
<td>1152 ± 1598</td>
<td>1694 ± 1910**</td>
<td>1530 ± 1586*</td>
<td>1497 ± 1436*</td>
<td>1417 ± 1368*</td>
<td>61</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Diet Energy kJ/day</td>
<td>9656 ± 3439</td>
<td>9598 ± 2895</td>
<td>7293 ± 1828**</td>
<td>7965 ± 1422**</td>
<td>8061 ± 2277**</td>
<td>8793 ± 1848</td>
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<tr>
<td>Cholesterol mg/ml/day</td>
<td>24.8 ± 6.4</td>
<td>25.3 ± 7.3</td>
<td>24.0 ± 6.5</td>
<td>24.3 ± 7.7</td>
<td>23.5 ± 6.8</td>
<td>22.7 ± 7.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat %</td>
<td>37 ± 9</td>
<td>36 ± 8</td>
<td>31 ± 6**</td>
<td>32 ± 6**</td>
<td>34 ± 6*</td>
<td>35 ± 7*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monounsat. FA %</td>
<td>12 ± 3</td>
<td>13 ± 3</td>
<td>10 ± 3**</td>
<td>12 ± 2**</td>
<td>12 ± 2</td>
<td>11 ± 3*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyunsat. FA %</td>
<td>10 ± 3</td>
<td>9 ± 4</td>
<td>9 ± 2</td>
<td>9 ± 2</td>
<td>9 ± 3</td>
<td>10 ± 3</td>
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</table>

Table 3. Life style risk factor. Physical activities assessed with the Minnesota Leisure Physical Activity Questionnaire (23). Diet was evaluated with the “vet expres”(24). [Abbreviations: FA = fatty acids; monounsat. = mono unsaturated; polyunsat = polyunsaturated; HF = high-frequency group; LF = low-frequency group]. [* significant change versus baseline (t1); p < 0.05; ** = significant change versus baseline (t1); p < 0.005; # = significant difference between HF and LF; p < 0.05].
DISCUSSION

The present study demonstrated that beneficial effects on exercise capacity and life-style changes tend to decrease gradually after CR during a year follow-up. Although changes of life-style tended to be better adapted and improvements on endurance exercise capacity better sustained after the HF-program, a higher frequency of exercise training was not enough to prevent this gradual decrease. Therefore, additional strategies should be developed for long-lasting adaptations of life-style.

*Exercise capacity.*

Short-term effects of both programs were reported earlier by our group\(^{10,11}\). A remarkable outcome was the high improvement of the VAT during a HF-program, which proved to be significantly higher than during a LF-program. Within a few weeks VAT and peak workload could be improved tremendously with a HF exercise training program without adverse events and this could be kept up with small effort. The present study demonstrates that such a high improvement of exercise capacity could be consolidated with a maintenance stage of only one exercise session a week. However, when patients became self-supporting after finishing supervised exercise training in the rehabilitation centre, many of them could not continue regular physical exercise at the same level and exercise capacity slightly decreased. Probably, many patients found it hard to implement regular physical activities into their normal daily life despite the fact that most patients were highly motivated and also encouraged repeatedly by us. Not only a busy schedule in their regular, successfully restored, daily life might be a problem. Also, many patients face the problem, that there are not enough facilities and opportunities for exercise training for these patients. Specialised sports clubs for heart patients have hardly sessions scheduled after a regular workday, while other (regular sporting) clubs are frequently reluctant that heart patients join them. In addition, exercise capacity might be substantially decreased following a period of (bed) rest due a new cardiac event or other conditions.

Strategies to improve physical active lifestyle should be aimed also at these problems. During a CR program, patients should be prepared to implement regular physical activities in their life. Next, facilities should be improved for what is called phase III CR at community basis. Last, patients should be taught during CR how to recover and to restore their exercise capacity after a fall back due to new conditions or events, or vacations.

Remarkable outcome was that patients of the HF-group tended to consolidate their physical activities at a higher level compared to baseline. A higher frequency of exercise training in phase II rehabilitation might therefore be a way to improve lifestyle. However, effects on lifestyle have to be maintained for many years to be effective as preventive measure for coronary artery disease. Whether the effects of HF-program will extent over a period of years is not elucidated by this study.
LV-function.
LV function did not deteriorate during both programs. This observation is in line with other reports. Analysis demonstrated also no determinants of deterioration of LV function, even of patients with an impaired LV function. We might therefore conclude, that a HF-program could be applied not only in patients with a normal but also an impaired LV function without further deterioration of LV-function. Data of our study even suggest that LV-function tended to improve during CR, an observation also in line with the results of the EAMI-trial. The EAMI-trial evaluated the effect on remodelling of the LV during exercise training early after an anterior wall myocardial infarction. They rebutted the idea that exercise training might deteriorate LV function in these patients, as it was earlier suggested in an uncontrolled study. In contrast, they found that exercise training tended even to improve LV function. It should be noted that the design of the EAMI trial and of our study differs considerably. First we focused not on patients suffering an anterior wall infarction. We included also patients with other myocardial infarction or even no infarction. Next, the time between event and exercise training was greater in our study. Furthermore, exercise training lasted longer (6 months) in the EAMI trial. This is of particular interest because it has been suggested that effects on cardiac functioning are to be expected after a longer period of exercise training. At last, remodelling was not the issue of our study. We compared HF with LF on effects of exercise capacity and QoL and examined whether HF did not worsen LV function. However, the small, non-significant, difference in LV-improvement between both programs might deserve further studies, especially because the frequency of our HF-program was also of higher than of the intervention in the EAMI-trial.

Quality of Life.
Conform its effect on exercise capacity, both CR-programs improved also QoL on most parameters. This fast recovery was especially reached with the HF-program with a significant greater improvement of mental health and distress. A gain of weeks, when compared with LF, might be less relevant from an epidemiological standpoint, for the individual patient it may be very important. Also a fast recovery might lead to a faster return to work.

In contrast to exercise capacity, the improvement of QoL was kept up at follow-up also after finishing the maintenance stage. However, the observed differences in efficacy equalised between both programs with respect to QoL, which could be expected. Psychic functioning is a resultant of many influences. CR is only a momentary factor, which determines QoL partly at that moment. After completing the program, influences of outside will increase, while the influence of the program itself will decrease gradually.

Self-efficacy is a parameter until now hardly used in outcome assessment of CR. This study demonstrates that self-efficacy improved during CR and that there was a borderline significant difference in favour of LF. We think that self-efficacy is an important outcome parameter. It is related to the ability of patients to recover from setbacks. These setbacks might be caused by recurrent manifestations of coronary heart disease (a condition of chronic nature with the treat of relapses) or by other conditions.
Therefore, patients should be prepared for these setbacks and should be taught how to recover emotionally and physically in general.

Secondary Prevention.

Prevention of new coronary events is vital and should be a major issue during CR. Especially during CR, patients can be motivated and encouraged to change lifestyle, are better aware of their health status, and are more open for education. Also, they can implement advice right away during the program. This gives cardiac rehabilitation a major advantage over regular in-hospital and outpatient cardiologic care. It is questionable whether frequency of exercise training is an important determinant of changes of lifestyle. The impact of different frequencies of exercise training might be too small for a substantial change of lifestyle. Nevertheless, we observed a significant beneficial effect of a HF program on diet compliance (especially energy intake) one year after finishing the CR-program, while physical activities tended to increase more after this program. It should be emphasised that also in the HF group the effects decreased gradually during the year follow-up, but they decreased more pronounced in the LF-group. Because lifestyle-changes have to be kept for many years to be effective in (secondary) prevention, it is too early to claim that a higher frequency of exercise training is more effective with this respect. In addition, most CR-programs use not only exercise training as treatment modality. In this study also a multidisciplinary program was applied with different components, i.e. patient education and counselling on emotional problems and lifestyle. Control for smoking was satisfactory and comparable in both groups. Remarkably few patients smoked when they entered the CR-program, as compared with a comparable group of patients in the Netherlands. Already at baseline, few patients smoked and many just quit smoking. Important is the observation, that only a few patients resumed smoking. This might be a result of CR itself. However, it might also be a bias due to a preferential referral of highly motivated patients. On the other hand, patients can be also referred because of problems with change of life style.

Study-limitations.

The present study did not use a control-group of patients that did not participate in a CR program. This was considered, but finally rejected for several reasons. As the main question of this study was to study the influence of frequency of exercise training and not whether cardiac rehabilitation was effective. Next, even a control group would not be a pure control group. Patients randomised to this group should be asked first and motivated to participate in this rehabilitation trial. This itself would be an intervention, because patients would be aware that they received no treatment.

CONCLUSION

High frequency exercise training generates a better short-term outcome on endurance exercise capacity and health related QoL and might be preferred if a rapid recovery or a great improvement of exercise capacity is necessary. However, on the
long term the effects of both programs become comparable. Beneficial short-term effects on exercise capacity and on life-style decrease in the long run and other strategies should be considered to sustain the initial improvement on exercise capacity and life style. The effects on life-style tended to better preserve after high-frequency exercise training.

References


