Long-Term Follow-up Study of Survival and Recurrence Rates following Myocardial Infarction in Exercising and Control Subjects

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SUMMARY
Male subjects \(N = 68\), under age 51 years, with previous myocardial infarction, who participated in a program of graduated exercises over a 7-year period \(1964-71\), have been compared with a control group \(N = 131\) for incidence of nonfatal recurrence and cardiac death. The controls fulfilled the criteria to enter the exercise program, but did not. Of the 68 exercising subjects, 66 were traced in January 1971. Two \(3.0\%\) had had a nonfatal recurrence. Of the 131 control subjects, only 117 gave valid information concerning possible recurrence. Thirteen \(11.1\%\) had suffered a nonfatal recurrence \(P < 0.10\). The incidence of cardiac death \(7.6\%\) was significantly lower \(P < 0.05\) in the exercising subjects than in the 127 control subjects \(4\%\) of the 131 could not be traced.

In 1969 a separate comparison of recurrence and survival over a 5-year period was made between 77 exercising subjects who had remained in the program for a minimum of 3 months and 127 control subjects in Toronto. One \(1.3\%\) of the exercising subjects had had a nonfatal recurrence, and 31 \(27.9\%\) of 111 Toronto control subjects \(16\%\) others were alive but information on recurrence was lacking gave a history of nonfatal recurrence \(P < 0.001\). There were three \(3.9\%\) deaths in the exercise group and 15 \(11.8\%\) deaths in the Toronto control group \(P < 0.10\).

Variables affecting prognosis, but not included in the study, were blood pressure, prior angina, and current angina. Although results of this investigation suggest that an exercise program in a selected group may favorably affect prognosis following recovery from myocardial infarction, they should be interpreted cautiously. One or more variables not related to the exercise program per se may have been operative in producing the apparent benefit.

**Additional Indexing Words:**
Coronary heart disease  Prognosis following infarction  Cardiac death

Numerous epidemiologic studies\(^1\)\(^-\)\(^5\) have suggested the possible beneficial effect of physical activity in reducing the occurrence of myocardial infarction. As reconditioning programs have been developed for postcoronary patients, various reports have described the positive psychic changes\(^6\) and increased cardiovascular endurance,\(^7\)\(^,\)\(^8\) as well as favorable modifications of some risk factors such as serum lipids\(^9\)\(^,\)\(^10\) and obesity.

At the University of Western Ontario a program of graduated exercises for postcoronary patients was begun in 1963. The program structure as well as some of the psychological, biochemical, and fitness changes have been...
reported earlier. In June 1969 and December 1970 our subjects were compared for evidence of recurrence and death, with two control groups of postinfarct patients, one in Toronto and the other in London, Ontario.

**Material and Methods**

Entry into the exercise program was restricted to volunteer male subjects who had sustained an acute myocardial infarction at least 5 months previously, were under 51 years of age at the time of the infarction, were nondiabetic, had a diastolic blood pressure less than 120 mm Hg, were free of any orthopedic disability preventing physical exercise, and were free of heart failure. There were 68 subjects who had been in the study for at least 1 year in the 7-year follow-up comparison with the London control group (1964–71) (see table 1). Two subjects were lost to follow-up study and are not included in the statistical evaluation. In an earlier comparison (1964–69) with a Toronto control group, any individual who had stayed in the exercise program for 3 months or longer was included in the total of 77 subjects.

The London control group was selected from the Medical Records Departments of the two major hospitals and consisted of all patients discharged between January 1960 and June 1969 with a proven diagnosis of myocardial infarction, who met the above criteria for entry into the program but who, for a variety of reasons, did not join. These included family-physician disapproval, shift work, lack of interest, or simply unawareness that such a program existed. There were 131 subjects in the total London control group, four of whom could not be traced and who are not included in the results.

The 68 exercising subjects were matched with 71 subjects from the London control group who resembled them most closely in age and in year and number of myocardial infarctions. The mean age of the 68 exercising subjects was 42.37 years, and the mean age of the matched controls was 42.61 years. Each control subject was known to be alive and free of recurrence at the time his matched exercising subject entered the program, and the interval between the myocardial infarction and entry into the study was at least as great for each control as for the matched exercising subject. Evidence of recurrence in all subjects included definite ECG and/or significant enzyme changes in the presence of convincing clinical evidence.

In 1969, comparison of recurrence and mortality rates were made between the 77 subjects who had entered the exercise study during the 5-year period 1964–69 and 127 matched control subjects in Toronto. The control subjects were obtained from the Medical Records Departments of the Toronto General and St. Michael’s Hospitals. They consisted of patients who had been discharged from the hospital following an acute myocardial infarction, who met the entry criteria of the exercise program, but who, from a reply to an activity questionnaire, had not participated in anything other than leisurely recreational activity. The control subjects were matched for age, year of infarction, number of infarctions, and occupational category. In 16 of the 127 Toronto subjects there was inadequate information to make any assessment as to whether there had been recurrence of infarction, although the 16 were known to be alive.

**Results**

The control subjects with inadequate documentation of possible recurrences were excluded from the analyses of relative recurrence rates. Since those subjects were known to be alive, however, it was appropriate to include them in analyses of death rates. The numbers (N) on which the computations of percentages and Chi-square analyses were based are shown in table 2.

**The London Control Group**

Table 2 shows no significant difference in recurrence in the matched controls and those left over after matching. Of the 69 matched controls who could be traced, there were 64 on whom adequate documentation of possible recurrence was obtained and had occurred in eight (12.5%). In the remaining 58 controls who could be traced, 53 had adequate documentation and five (9.4%) had had a recurrence. Thus, there was no significant difference (P = 0.90 Chi-square test) in recurrence rate between the matched controls and the total control group.

Of the 69 matched controls, 10 (14.5%) had died from coronary heart disease. In the remaining controls 14 (24.1%) had died (see

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**Table 1**

<table>
<thead>
<tr>
<th>Exercise Subjects—Length of Time in Program (1964–71)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (yr)</td>
</tr>
<tr>
<td>No. of subjects</td>
</tr>
</tbody>
</table>

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table 2). The matched controls, therefore, were representative of the total London control group which had a death rate of 18.9%.

Exercising Group and Total Control Group

Comparison between the exercising subjects and the total London control group is shown in table 2. The incidence of recurrence (3.0%) tended to be lower \( (X^2 = 3.66; P < 0.10) \) in the exercising subjects than it was in the 117 control subjects on whom adequate documentation of possible recurrence was available. In this group there were 13 (11.1%) recurrences. The incidence of cardiac death (7.6%) was also significantly lower \( (X^2 = 4.36; P < 0.05) \) in the experimental subjects than in the 127 control subjects who could be traced (18.9%).

Exercise Group and Matched Controls

There was a significantly lower incidence of recurrence \( (X^2 = 4.10; P < 0.05) \) in the exercising group compared to the matched controls (see table 2). The incidence of cardiac deaths also was higher for the controls than for the exercising subjects but the difference was not significant \( (X^2 = 1.63; P < 0.20) \).

Exercise Group and Toronto Controls

Of 77 living exercising subjects, one (1.3%) had had a recurrence, though 31 (27.9%) of 111 living Toronto subjects for whom adequate documentation was available gave a history of recurrence \( (X^2 = 22.83; P < 0.001) \). There were three (3.9%) deaths in the exercise group over the 5-year period, while 15 (11.8%) deaths occurred in the Toronto control group \( (X^2 = 3.73; P < 0.10) \) (see table 3).

Discussion

The data suggest that a training program will reduce the likelihood of recurrence and

Table 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Total no.</th>
<th>No. traced</th>
<th>Alive but other information lacking</th>
<th>Nonfatal recurrence</th>
<th>Cardiac death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise group</td>
<td>68</td>
<td>66</td>
<td>0</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>((97.06%))</td>
<td>((N = 68))</td>
<td>((3.03%))</td>
<td>((N = 66))</td>
<td>((7.58%))</td>
</tr>
<tr>
<td>Total London controls</td>
<td>131</td>
<td>127</td>
<td>10</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>((96.94%))</td>
<td>((N = 131))</td>
<td>((7.87%))</td>
<td>((N = 127))</td>
<td>((11.11%))</td>
</tr>
<tr>
<td>Matched controls</td>
<td>71</td>
<td>69</td>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>((97.18%))</td>
<td>((N = 71))</td>
<td>((7.25%))</td>
<td>((N = 69))</td>
<td>((12.50%))</td>
</tr>
<tr>
<td>Remaining controls</td>
<td>60</td>
<td>58</td>
<td>5</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>((96.66%))</td>
<td>((N = 60))</td>
<td>((8.62%))</td>
<td>((N = 58))</td>
<td>((9.43%))</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Table 3

Comparison of Recurrence and Mortality between Exercising Subjects and Toronto Control Group (1964–69)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total no.</th>
<th>Alive but other information lacking</th>
<th>Nonfatal recurrences</th>
<th>Cardiac deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercising subjects</td>
<td>77</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.29%)</td>
<td>((N = 77))</td>
<td>(3.89%)</td>
</tr>
<tr>
<td>Toronto controls</td>
<td>127</td>
<td>16</td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12.39%)</td>
<td>((N = 127))</td>
<td>(11.81%)</td>
</tr>
</tbody>
</table>

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death in a selected group of patients who have survived an acute myocardial infarction. However, in the Toronto control group, the apparently high nonfatal recurrence rate may be related to less rigid criteria for documentation. Although some were well-documented recurrences, in some instances it was necessary to accept historical evidence of patient and physician without scrutiny of the ECGs by the authors. This possible source of error does not exist in the assessment of nonfatal recurrence in the local control group (London controls). In addition, several variables known to have a bearing on prognosis following myocardial infarction were not controlled. These include hypertension, prior angina, and current angina. It may be that the Toronto and London control groups were unfavorably weighted with these. It is recognized that there may have been other differences between the experimental and control groups which conceivably could have biased the study in favor of the exercising subjects. For example, subjects who enter a rehabilitation program voluntarily may differ psychologically from those who do not, in a way that might affect prognosis. Our own experience indicates that subjects do experience significant and favorable mood changes as the result of participating in a cardiac rehabilitation program. Perhaps these mood changes, in some way, influence prognosis favorably.

If exercise is the variable responsible for the reduction in recurrence, several mechanisms might be invoked. Increased collateral supply, known to occur in the experimental animal, may develop in the patient with coronary heart disease who participates in an exercise program. Whether this occurs to a significant extent and whether it has a protective effect is not yet known. Perhaps the increased circulatory efficiency that comprises the cardiac response to exercise, including a reduction in heart rate and increase in stroke volume for a given oxygen uptake after training, was important. Subjects who enter a rehabilitation program frequently stop smoking and lose weight. Some or all of these factors may explain the apparent benefit of an exercise program on a long-term prognosis.

The results of this investigation point to the need for a tightly controlled long-term prospective study. In addition, research must be continued into the mechanisms by which exercise apparently produces beneficial changes in the cardiovascular system of patients with coronary heart disease.

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