The Exercise Test and Prognosis of Coronary Heart Disease

By George E. Dimond, M.D.

The significance and prognostic value of the exercise test in coronary heart disease remain controversial. Robb and associates found significantly higher rates of death and occlusion in those with a positive test and stated that a negative response to the double two-step exercise test excludes, for practical purposes, the presence of latent coronary insufficiency and clinically significant narrowing of the coronary arteries. Lepeschkin reported that a completely normal electrocardiographic response to the double Master exercise test indicates with great probability that no major coronary stenosis is present, or, if present, it is well compensated by collateral circulation. Wood and associates permitted 100 patients with classical angina pectoris to exercise until symptoms developed and obtained an ischemic response in 88 per cent. Scherf stated that it is apparently impossible to exclude false-negative tests and that any conclusion as to prognosis, based on the outcome of an exercise test, is unjustified.

The type of response to exercise in which the S-T segment is depressed 0.5 mm. or more below the P-R or P-Q junction in a horizontal or sagging course has been described as significant of myocardial ischemia by Wood and associates and by Myers and Talmers. Robb and associates found this to be the best and only unequivocal criterion for a positive test. Brody examined 756 business executives free of clinical coronary heart disease and found 23 with this ischemic type of response. Definite coronary artery disease later developed in 70 per cent of these 23 men. Myers and Talmers; Robb and associates, and Brody all found that S-T junctional depression, if deep and not due to tachycardia, could indicate myocardial ischemia in some cases.

This report is a 5-year follow-up study of 153 railway operating employees with known or suspected coronary artery disease who were examined with an exercise test to estimate their ability to continue work in a vigorous and responsible occupation.

Material and Methods

Railway operating employees are subject to periodic examinations to determine physical fitness. Those with cardiovascular diseases are followed closely and, under the direction of the late Gordon B. Myers, electrocardiograms have been used routinely in the medical director's office since 1938. One purpose of these examinations is the detection of latent or concealed coronary artery disease, and the electrocardiographic exercise test is used in selected cases.

The men in this report were actively employed when tested, and the majority were being followed for cardiovascular disease. Thirty-six had returned to work after a myocardial infarction, 83 had hypertension or valvular heart disease, 25 had chest pain suggesting angina pectoris, and nine were obese or had diabetes. None taking digitalis was included.

Indications for an exercise test were minor depressions of the S-T segment or the S-T segment junction, and lowered or flattened T waves, particularly when these findings were a change from previous electrocardiograms. It was recognized in many men that these changes were probably due to hypertension, and the exercise test was performed to detect coexistent coronary artery insufficiency.

Another indication was chest pain suggesting angina when the resting electrocardiogram was normal or not diagnostic of acute subendocardial injury. In men with recent onset of pain or progressively severe pain, the exercise test was postponed till it was clear that acute infarction was not impending. Some hypertensive passenger engineers, because of their increased responsibility, were tested despite normal electrocardiograms and freedom from symptoms. The major characteristic of the resting electrocardiograms is shown in table 1.

For practical reasons, all men did the same amount of exercise consisting of 40 ascents of the...
Table 1

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<tr>
<th>Major Characteristics of Resting Electrocardiograms</th>
<th>Number</th>
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<tr>
<td>Old myocardial infarction</td>
<td>37</td>
</tr>
<tr>
<td>Left ventricular hypertrophy or strain</td>
<td>61</td>
</tr>
<tr>
<td>Normal</td>
<td>42</td>
</tr>
<tr>
<td>Normal, except for nonspecific S-T segment or T-wave changes</td>
<td>13</td>
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</tbody>
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standard 9-inch step described by Master. They were asked to do the exercise as rapidly as they could with comfort. Almost all completed the test in 60 to 90 seconds. Since the average age of these men was 59 years, and most were of average weight, this test is roughly equivalent to or in excess of the double Master exercise test. One electrocardiogram was taken immediately after exercise, in most instances with leads V₃ through V₅ followed by the unipolar and standard leads in reverse order as recommended by Myers and Talmers. Those with a typical ischemic response after exercise were considered to have positive tests. The remainder, including those with S-T junctional changes, were considered negative.

The exercise tests were done prior to January 1, 1956, and all men were followed to January 1, 1961. The incidence of myocardial infarctions and causes of death during the follow-up period were determined by re-examinations, reports from attending physicians, death certificates, and records of the United States Railroad Retirement Board. In those dying suddenly, the diagnosis of myocardial infarction on the death certificate was accepted.

Results and Discussion

Thirty-seven tests were positive and 116 were negative. The incidence of myocardial infarction during the 5-year follow-up period after the test was approximately three times greater in those with a positive test and the death rate was almost double. These differences are of statistical significance. In those with an ischemic response all but two of the deaths were due to myocardial infarction. Half of the deaths in the group with a negative test were due to myocardial infarction and the remainder was largely due to complications of hypertension. The prognosis of some in the negative group was adversely effected by hypertension, and the test is probably a greater discriminator regarding survival than is shown in Table 2.

Twenty-one men with a positive response to exercise escaped a myocardial infarction during the 5-year period after the test. Eighteen are living. One died of a myocardial infarct 10 years after a positive test and two died of causes not related to coronary heart disease. The average duration of life to date after the recording of a positive test is 7 years. Six men are still actively employed, nine retired in the usual manner between ages 65 and 70, and five retired for disability usually due to coronary artery insufficiency. The better prognosis observed in more than half of those with positive tests is presumably due to the development of better collateral circulation, which allowed them years of productive life after an ischemic response was recorded.

Eleven men were thought to have classical angina pectoris despite a normal resting electrocardiogram and a negative response to exercise. Seven had a myocardial infarct within 6 years and three others retired for incapacitating angina. In view of their symptoms and subsequent history, these men were considered to have false-negative tests.

The medical director does not base disability on the results of the exercise test alone. Those with positive tests were permitted to continue work if incapacitating symptoms were not present. Some were restricted to positions in which sudden death or disability would not be hazardous to others. Three men were temporarily removed from service because of a marked ischemic response to exercise, despite minimal symptoms. None complained of pain following the test, and no myocardial infarctions were precipitated. If complications are to be avoided, the test

Table 2

<table>
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<tr>
<th>Response to exercise</th>
<th>Number</th>
<th>Myocardial infarct</th>
<th>Dead</th>
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<tbody>
<tr>
<td>Positive</td>
<td>37</td>
<td>16 (43%)</td>
<td>13 (35%)</td>
</tr>
<tr>
<td>Negative</td>
<td>116</td>
<td>16 (14%)</td>
<td>22 (19%)</td>
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should not be used when preinfarction angina is suspected, and the amount of exercise used should not greatly exceed that encountered by the man in his daily activities.

Left ventricular hypertrophy or strain in the resting electrocardiogram may lead to a false impression of an ischemic response after exercise. The S-T segment may sag more without significant depression of the S-T segment junction, or the S-T segment may be depressed due to tachycardia without change in its contour. Only those tests in which the whole S-T segment is depressed and the contour of the segment is significantly changed from the resting stage should be considered ischemic.

Summary and Conclusion

In a 5-year follow-up study of 153 railway operating employees examined with an exercise test, the incidence of myocardial infarction was approximately three times greater in those with a typical ischemic response and the death rate was almost double.

The ischemic response to an exercise test indicates transient coronary artery insufficiency and has prognostic implications of statistical significance in a large group. Application of these prognostic implications to the individual is limited by the frequency of false-negative tests and the presumed ability of collateral circulation to compensate for coronary artery insufficiency.

References


Religio Medici

Lastly, if length of Days be thy Portion, make it not thy Expectation. Reckon not upon long Life: think every day the last, and live always beyond thy account. He that so often surviveth his Expectation lives many Lives, and will scarce complain of the shortness of his days.—Sir THOMAS BROWNE. *Religio Medici*, 1642, edited by W. A. Greenhill, M.D., Oxon., London, MacMillan and Co., Limited, 1950, p. 231.
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