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PROBLEMS IN AEROMEDICAL CERTIFICATION

Cardiovascular Response to Exercise Following Myocardial Infarction

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FOREWORD

A major question in aviation medicine concerns the aeromedical certification of airmen with a history of myocardial infarction. Cardiac-rehabilitation research has recently been initiated and advanced on a national scale with very promising results. Return to full duties without symptoms has been found possible. Many individuals attain a better cardiovascular status than they had before their "heart attacks."

A return to full duty is important for the economic and emotional well-being of each airman concerned. Aviation safety can be improved by rehabilitation of these aviation personnel, development of the optimum means of assessing each airman to determine his qualifications for return to full duties, and by an exercise program to prophylactically reduce the prevalence of heart disease.

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I. Introduction.

An important question for the clinician is whether or not a myocardial infarction necessarily impairs the capacity of the heart for work. Many physicians restrict indefinitely the physical activity of their post-infarction patients. Others prescribe physical training or conditioning. The present study was undertaken to ascertain differences, if any, between post-infarction patients and healthy subjects with respect to cardiovascular responses to the demands of physical exertion and to test the ability of post-infarction patients to undergo physical conditioning.

II. Methods and Materials.

Thirty-six men, twenty-four who had recovered from well-documented episodes of myocardial infarction occurring within 2 to 15 months of the study and twelve who were apparently in good health, were studied. They were all inially classified as sedentary because, although they were engaged in their usual occupational and recreational activities, they did not participate regularly in sports or physical exercise. After the initial period of evaluation, 12 of the postcoronary patients volunteered for a physical conditioning program. The other 12 and the 12 presumably healthy men remained "sedentary." Each group of 12 subjects was matched as nearly as possible for age, height, and weight.

All of the subjects were tested and retested in the same manner. Blood pressure was determined by the auscultatory method during rest, standing, and the last half of each minute of walking. Pulse rate was recorded simultaneously with a 15-second electrocardiographic tracing and by a 15-second auscultatory count determined concurrently with the blood pressure. All measurements were monitored by the same observer.

Walking was performed on a motor-driven treadmill. Each subject performed a test, measured by the Douglas-Haldane technique,[1] designed to impose energy demands no greater than seven time those of the resting metabolic state. A subject began the walk on a level grade at 2.0 mph. The speed was held constant while the treadmill bed was elevated 3.5% every 3 minutes. The test was terminated after 18 minutes or earlier if the subject developed chest pain, claudication, or severe dyspnea.

The physical conditioning was conducted under medical supervision. The "training cardiacs" engaged three times a week in an hour-long medically-supervised exercise session consisting of competitive games, calesthenics, and noncompetitive jogging. Each subject gradually increased his level of energy expenditure.

In the statistical analysis, the training cardiac patients served as their own controls. Their responses before and after training were compared.

The twelve healthy men served as a control group for the sedentary cardiacs. Their responses during each test were evaluated to determine if a significant interaction occurred between the groups. The responses within a group to similar amounts of physical exercise were compared to determine whether or not repeating the procedure was accompanied by an altered physiological response.

Since all men did not complete the entire standard testing procedure, the statistical analysis was limited to those measurements recorded during the first 12 minutes of walking. Systolic and diastolic blood-pressure measurements were treated independently in the analysis.

III. Results.

A. *Group Characteristics.*

The three groups were almost ideally matched for age, height, and weight (Table 1). Very little change in mean body weight was observed in any of the groups during the study.

B. *Cardiovascular Responses During Rest and Standing.*

Consistently lower values were recorded for the systolic and diastolic blood-pressure in the sedentary controls than for the sedentary cardiacs (Table 2). These same values were slightly

Table 1. The groups were closely matched for age, height and weight.

	N	Age	Height (cm)	Weight (kg) Test 1	Weight (kg) Test 2
Training cardiacs	12	48.1	176.0	77.5	76.8
Sedentary cardiacs	12	47.1	173.9	76.1	75.7
Sedentary controls	12	48.4	178.3	76.9	80.0

different during the second evaluation in the training cardiacs. Before physical conditioning was initiated, their responses were similar to those of the sedentary cardiacs, but 8 months later, the determinations were more near those observed in the sedentary controls.

Initially, the resting pulse rates were nearly identical for each group (Table 2). Eight months later, the mean pulse rates were lower in those cardiacs who had exercised, but were unchanged in the two sedentary groups. A similar pattern was observed during standing.

C. *Responses During Treadmill Walking.*

1. *Systolic Blood Pressure.*

During the initial test, the systolic blood-pressure response was similar in each group at comparable levels of energy demand (Figure 1). Eight months later, the mean values were lower P 0.05) throughout the testing procedure in the cardiacs who had exercised, but unchanged in the two sedentary groups. There was no significant interaction between the two sedentary groups, indicating that the presence of disease did not alter the cardiacs' ability to adjust to the physical stress.

2. *Diastolic Blood Pressure.*

Again, the training cardiac had decreased diastolic blood-pressure values (P 0.05) during the second test, whereas the diastolic pressures of the sedentary groups had determinations which approximated those recorded during the first test (Figure 2). There was no significant interaction between the first and second tests of the two sedentary groups. The sedentary cardiacs had slightly higher diastolic blood pressures during the tests than did either of the other two groups of men.

Table 2. Blood pressure and pulse rate decreased during rest and standing in the cardiacs who trained, but remained essentially unchanged in the two sedentary groups

	N	Blood pressure mm (Hg) Supine Test 1	Blood pressure mm (Hg) Supine Test 2	Blood pressure mm (Hg) Standing Test 1	Blood pressure mm (Hg) Standing Test 2	Pulse rate Supine Test 1	Pulse rate Supine Test 2	Pulse rate Standing Test 1	Pulse rate Standing Test 2
Training cardiacs	12	134/85	130/83	133/89	126/86	68	61	83	67
Sedentary cardiacs	12	136/91	140/90	139/85	139/94	71	70	82	83
Sedentary controls	12	124/83	130/82	128/87	138/87	72	73	87	86

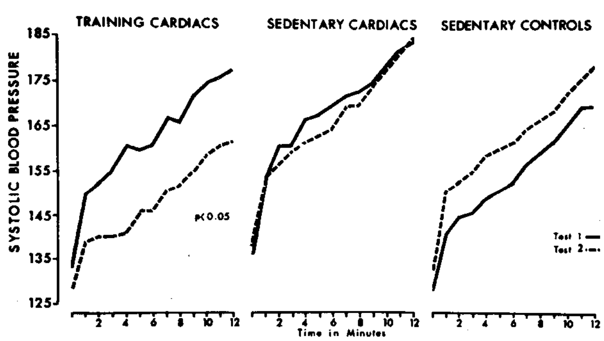

Figure 1. There was a significant decrease in the level of systolic blood pressure following physical conditioning in the training cardiacs, whereas no difference was observed with retesting in either sedentary group. hTe response of the sedentary cardiacs was similar to that observed in the sedentary controls. (The values represent the mean determination for 12 subjects.)

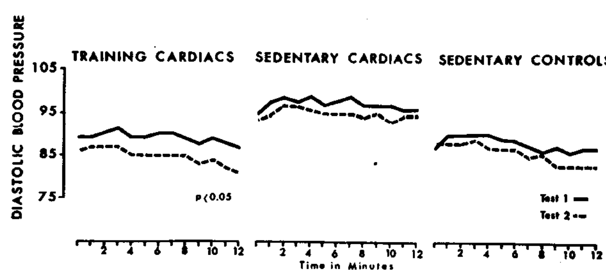

Figure 2. Significant decreases in diastolic blood pressure were observed in the training cardiacs, whereas no differences occurred in either sedentary group. The sedentary cardiacs consistently had higher diastolic-blood-pressure determinations than the other two groups. (All values represent the mean determinations for 12 subjects.)

3. *Pulse Rate.*

The alterations that were observed at rest and standing in the training cardiacs were also observed during exercise (Figure 3). At each comparable oxygen requirement, the pulse rate was 12 to 20 beats per minute lower (P 0.05) in the training cardiacs; no difference was observed in the sedentary men. In the initial tests, the mean pulse rates were 122 for the training cardiacs, 129 for the sedentary cardiacs and 126 for the sedentary controls during the 12th minute of walking. Eight months later, these values were 103, 126 and 120, respectively.

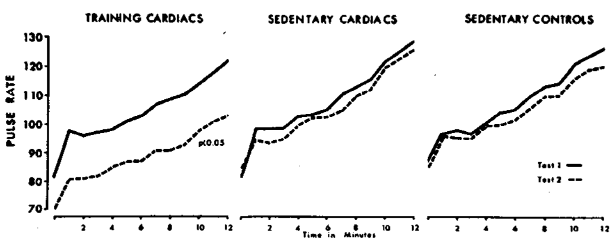

FIGURE 3. The pulse rate was 12 to 20 beats per minute lower throughout the test following the physical conditioning. Retesting did not influence the pulse-rate response in either sedentary group. The adaptations of the two sedentary groups were quite similar throughout the tests. (All values represent the mean determination for 12 subjects.)

D. *Mean Test Performances.*

Eight of twelve controls and six of twenty-four patients completed the entire test initially (Table 3). Eleven of twelve training cardiacs performed the 18-minute test 8 months later, whereas only three of the twelve sedentary cariacs completed the second test.

IV. Discussion.

Several investigators have established physical-conditioning programs for cardiac patients. An early report [2] indicated that patients experienced clinical and psychological improvement during such a program. A more recent study [3] reported improvements in certain motor-performance tests in four cardiac patients during a conditioning program. Despite widespread interest in physical rehabilitation for cardiac patients, there are still no standardized guidlines with which to select patients, to evaluate the progress of each subject, or to establish the minimal level of activity necessary for achieving a conditioning effect.

These data indicate that the nonsymptomatic patient who has recovered from a myocardial infarction can develop a cardiovascular response consistent with that observed to occur in presumably healthy men following physical conditioning.[4, 5] These altered responses were observed during rest, standing and comparable levels of energy expenditure. The most objective measurement was the pulse rate, since it could be confirmed by electrocardiographic monitoring. The decreased pulse rate at comparable oxygen demands reflects an improved oxygen pulse, which is indicative of an increased cardiovascular efficiency.

These findings cannot be generalized to all post-infarction patients. Those with irreversible myocardial restriction from extensive scarring or fibrosis would not be expected to respond to physical conditioning. For example, one patient trained for 6 months and increased his daily activity tremendously. He claimed that he felt better throughout the conditioning. When he was re-evaluated, no differences in his cardiovascular adjustments during identical levels of physical stress were detected (Figure 4), indicating that he had lost the abilty to gain a conditioning response. His systolic blood-pressure response was of a lower magnitude than that observed in the other man and the pulse-pressure remained narrow throughout the test. Despite this limitation, he was able to perform the entire test. The

TABLE 3. All of the training cardiacs increased the duration of the test performance following training and only one stopped early. No changes in the mean duration were observed when the sedentary cardiacs were retested. Eleven of the 12 sedentary controls completed the second evaluation.

Duration of test	Training cardiacs		Sedentary cardiacs		Sedentary controls	
(min)	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
12	5	--	3	4	--	--
15	5	1	5	5	4	1
18	[illegible]	11	4	3	8	11

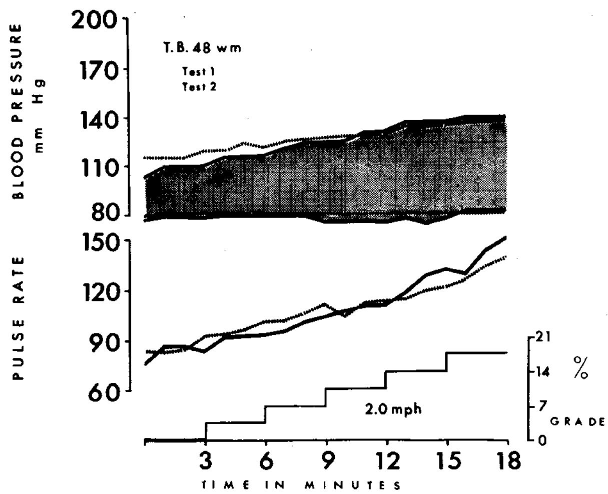

FIGURE 4. A 48-year-old white man was evaluated before and after 6 months of physical conditioning. No alterations were observed in his functional cardiovascular adaptations following the training, indicating that he had lost the ability to be reconditioned.

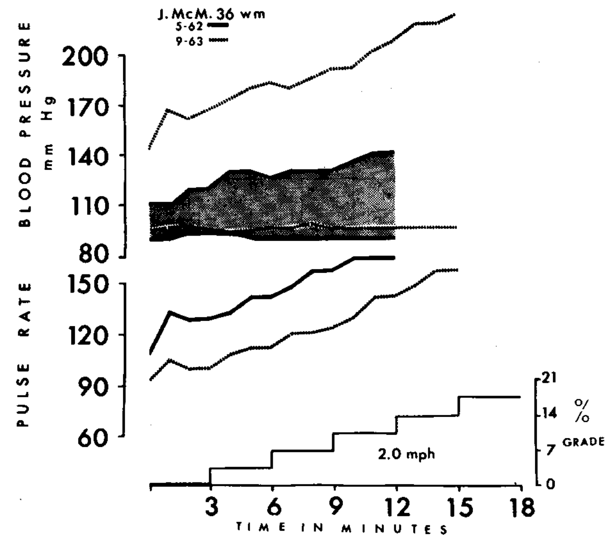

FIGURE 5. A 36-year-old white man was evaluated approximately 1 week before suffering a second myocardial infarction. His blood-pressure and pulse-rate responses were pathological and indicative of poor cardiovascular reserve. When evaluated 1 year later, his blood-pressure adaptation was consistent with a hypertensive response and the pulse-rate changes were essentially normal. These findings indicated that he had regained some myocardial reserve.

pulse-rate responses during both procedures were like those observed in the sedentary men.

The test may be of value if employed periodically for evaluating the functional adjustments of cardiac patients. The quality of the physiological responses may indicate that a patient has limitations even though he is nonsymptomatic. One patient was observed approximately 1 week before suffering a second myocardial infarction. During the initial evaluation, his resting and standing blood pressures and pulse rates were within normal limits. During walking, the pulse pressure remained narrow and the pulse rate rose steeply reaching 175/min at an oxygen intake only five times that of the resting metabolic state (Figure 5). No electrocardiographic abnormalities were recorded. These adjustments were definitely pathological and indicated that the patient had very little myocardial reserve. One year later, however, his cardiac reserve had been largely restored. The systolic blood pressure increased out of proportion to that usually observed at comparable levels of physical stress; the diastolic pressure rose slightly and remained modestly elevated; the pulse-rate rose in a more usual fashion. In addition, the patient did more work without any indication that he had reached his maximum capacity. Thus, the data from the first test indicated that this patient was not a satisfactory candidate for physical conditioning; after he convalesced further, a second evaluation showed him to have a good capacity for physical training.

V. Summary.

Thirty-six men, twenty-four with well-documented episodes of myocardial infarction and twelve presumably healthy, performed a work-capacity test while sedentary. All of them were re-evaluated 8 months later after 12 of the cardiac patients had participated in a physical-conditioning program and the remainder had remained sedentary. There were significant training effects in the exercising cardiacs as reflected by the systolic and diastolic blood-pressures and pulse-rates during rest, standing and comparable levels of energy expenditure. No differences were observed between tests in either the sedentary cardiac or sedentary healthy men. The response to physical stress was similar in cardiacs to that observed in the healthy men, indicating that the presence of disease did not necessarily affect the physiologic response of the subjects.

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