Arm Exercise Testing with Myocardial Scintigraphy in Asymptomatic Patients with Peripheral Vascular Disease*

Stacey Goodman, M.D.; Shirley Rubler, M.D., F.C.C.P; Hillel Bryk, M.D.; Bradley Sklar, B.S.; and Lynne Glasser, M.D.

Arm exercise with myocardial scintigraphy and oxygen consumption determinations was performed by 33 men with peripheral vascular disease, 40 to 74 years of age (group 2). None had evidence of coronary disease. Nineteen age-matched male control subjects (group 1) were also tested to determine the normal endurance and oxygen consumption during arm exercise in their age group and to compare the results with those obtained during a standard treadmill performance. The maximal heart rate, systolic blood pressure, pressure rate product, and oxygen consumption were all significantly lower for arm than for leg exercise. However, there was good correlation between all these parameters for both types of exertion. The maximal heart rate, work load and oxygen consumption were greater for group 1 subjects than in patients with peripheral vascular disease despite similar activity status. None of the group 1 subjects had abnormal arm exercise ECGs, while six members of group 2 had ST segment changes. Thallium-201 scintigraphy performed in the latter group demonstrated perfusion defects in 25 patients. After nine to 29 months of follow-up, three patients who had abnormal tests developed angina and one of them required coronary bypass surgery. Arm exercise with myocardial scintigraphy may be an effective method of detecting occult ischemia in patients with peripheral vascular disease. Those with good exercise tolerance and no electrocardiographic changes or metastatic defects are probably at lower risk for the development of cardiac complications, while those who develop abnormalities at low exercise levels may be candidates for invasive studies.

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FRP = pressure rate product

A close association has been found between peripheral vascular and coronary artery disease and the latter is a leading cause of morbidity and mortality in peripheral vascular disease patients in the perioperative period.1-5 Coronary artery disease may remain unrecognized prior to surgery because of the limitation of activity imposed by lower extremity claudication. Routine coronary arteriography before surgery has been advocated, but noninvasive stress tests, not dependent on lower extremity activity, could represent a feasible alternative in patients with no overt heart disease. One method of detecting latent coronary pathology has been to use dipyridamole and T1, but some patients have developed unwanted reactions to the drug. Another method has been to employ arm exercise in high risk subjects.6-14 Electrocardiographic monitoring alone during exercise has been found to be less sensitive6-10 in detecting abnormalities than when thallium-201 is added.19 We have therefore utilized a maximal stress test with arm exercise and myocardial scintigraphy in a group of subjects with documented peripheral vascular disease who had no overt evidence of coronary arteriosclerosis. Our objectives in the investigation were twofold: to assess the prevalence of coronary artery disease as elicited by stress electrocardiography and myocardial scintigraphy in patients with peripheral vascular disease. Secondly, since there is a dearth of data concerning the physiologic responses of middle-aged and elderly men to arm exercise, another purpose was to assess the exercise performance of healthy male subjects in this age group and to compare their performance with an arm cycle to that obtained by routine treadmill testing.

Material

Patient Selection

A survey of the hospital wards and the vascular surgery outpatient services of the New York Veterans Administration Medical Center was made to identify patients with peripheral vascular disease. After personal interview and review of the medical records, each candidate underwent arterial Doppler study, physical examination, electrocardiography, echocardiography and routine blood tests including serum cholesterol level. Only patients with claudication, physical signs of peripheral vascular disease, and a Doppler index ≤0.8 (ankle systolic pressure/brachial systolic pressure),15 with no abnormalities on echocardiogram or ECG and negative chest roentgenogram, who were free of valvular disease, myocardial infarction or angina were included. The only exceptions were one patient who had an intermittent atrial ectopic focus associated with an inverted T wave in leads 2, 3, and aVF and another patient who had frequent premature ventricular depolarizations. There were 35 men who qualified for the study. None could perform treadmill exercise because of leg claudication. However, all but two who were too weak, performed with an arm crank. The ages of the remaining 33 ranged from 40 to 74 years (mean 61.6±7.8 years) (group 2).
Twenty age-matched healthy male volunteers also entered the study but one of these subjects could not cooperate during exercise and was eliminated. The ages of the 19 men ranged from 45 to 78 years (mean 58.7 ± 9.5 years) (group 1). All subjects gave informed consent according to regulations established by the committees for human research and the investigational review boards of the hospital. The clinical data are summarized in Table 1. Hypertension was defined as systolic blood pressure of ≥140 mm Hg, a diastolic blood pressure ≥90 mm Hg or both, or a normal blood pressure on antihypertensive medication.

**METHODS**

**Exercise Protocol**

A multistage maximal arm exercise test was conducted on a Schwinn Air-Dyne ergometric exerciser which operated in such a manner that as the speed of operation increased, the resistance of the air to the wind vanes on the wheel provided a wide range of calibrated work loads. The subjects operated the device with the machine stationary on the floor using only the handles for arm exercise. All subjects were in the postabsorptive state and began exercising at a work load of 150 kpm/min. The load was increased by 150 kpm/min at three-minute intervals until exercise was terminated. In addition, the control subjects underwent a standard multistage maximal exercise test conducted on a motorized treadmill according to the Bruce protocol. The control subjects performed both exercise tests on the same day and were randomly assigned to arm exercise or treadmill first, with approximately one hour between tests to allow their exercise parameters to return to baseline. All control subjects were able to achieve at least 75 percent of predicted heart rate with arm exercise or 85 percent of predicted heart rate on the treadmill.

Standard 12-lead ECGs and systolic blood pressure determinations were obtained at rest, at one-minute intervals during exercise, immediately postexercise, and for each minute during the recovery period, for a total of at least five minutes or until the heart rate fell below 100 beats per minute. Simultaneous systolic blood pressure determinations were made with a variable sensitivity London pressuremeter (Avionics model 1906) or a Tyco sphygmomanometer. Expiratory gas was continuously monitored as it was drawn through apparatus equipped with oxygen and carbon dioxide analyzers coupled to a computer. Oxygen consumption, expired CO2 and respiratory quotient were recorded at 20-second intervals in 26 peripheral vascular disease patients and in 15 healthy control subjects. (Others could not tolerate the procedure.) Exercise was terminated in all subjects because of arm or leg fatigue. There were no episodes of angina or hypotension.

The exercise ECG was considered abnormal if a horizontal or downsloping ST segment depression of 1 mm or more occurred 0.08 second after the J point of the QRS complex in any lead during or after exercise. The following measurements and calculations were made:

1. Maximal pressure rate product (PRP max) = the maximal heart rate times the maximal systolic blood pressure/100.
2. Predicted PRP max was derived from the formula: 364-0.58 (age in years).
3. Work capacity represented product of exercise duration and workload.

**Myocardial Scintigraphy**

All group 2 subjects underwent myocardial scintigraphy with 99mTc by a method similar to that used in prior studies. Thirty seconds before the termination of exercise, 2.0 mCi of 99mTc were injected through an indwelling venous catheter, followed by a flush of normal saline solution. Scanning was begun with the patient in the supine position five to ten minutes after the completion of exercise. The views recorded were the anterior, left lateral, 45° left anterior oblique and 45° left anterior oblique with a 15° headward tilt of the camera (cephalad LAO). Scans were performed with a portable scintillation camera connected on line with computer system. A total of 400,000 counts were acquired in each view. The energy setting was 70 KEV with a 20 percent window.

At four hours after the injection, the four views were repeated in a reperfusion study. Scans were processed by the Starimager computer system using a locally developed program. Both filtered and unfiltered images were prepared for analysis. Unfiltered and filtered exercise and reperfusion views were interpreted independently by two experienced cardiologists who were blinded as to patients’ clinical data and identity. Significant discrepancies in interpretation were resolved by a third cardiologist.

**Echo-cardiography**

Technically satisfactory ultrasound studies were obtained in 17 group 1 and 30 group 2 subjects with a cardiac ultrasound unit. The echocardiograms were performed according to standard technique and measurements of wall thickness, left ventricular dimensions in diastole (LVDD) and systole (LVSD) were obtained. Fractional shortening was used as a measure of myocardial function: (percent fractional shortening = LVDD - LVSD / LVDD) × 100%.

**Data Analysis**

Statistical evaluation was accomplished by Student’s unpaired t-test between group 1 and group 2 and Student’s paired t-test between arm and treadmill exercise in group 1 subjects. Mann-Whitney U-Wilcoxon rank sum W test was used to compare smoking data between group 1 and group 2 and Pearson correlation with and without regression plots for comparison of exercise parameters.

**RESULTS**

**Comparison of Arm Exercise and Treadmill for Group 1 Subjects**

Eighteen control subjects underwent both treadmill and arm exercise. (One control subject performed arm exercise only.) Two control subjects in group 1 who were physically active were included in the comparison of the normal response to arm vs treadmill exercise, but not for comparison to the sedentary subjects in group 2.

**Heart Rate**

The heart rate at maximal stress was significantly higher in the control than in the patients.

<table>
<thead>
<tr>
<th>Clinical Data</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects</td>
<td>19</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Age, yr</td>
<td>58.7 ± 9.5*</td>
<td>61.6 ± 7.8</td>
<td>NS</td>
</tr>
<tr>
<td>Positive family history</td>
<td>5 (26.3%)</td>
<td>11 (33.3%)</td>
<td>NS</td>
</tr>
<tr>
<td>Cholesterol, mg/dl</td>
<td>214 ± 32</td>
<td>216 ± 52</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1 (5.3%)</td>
<td>9 (27.3%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Hypertension</td>
<td>2 (10.5%)</td>
<td>11 (33.3%)</td>
<td>NS</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 pk/yr</td>
<td>9 (47.4%)</td>
<td>3 (9.1%)</td>
<td>&lt;0.005*</td>
</tr>
<tr>
<td>1-29 pk/yr</td>
<td>3 (15.8%)</td>
<td>6 (18.2%)</td>
<td></td>
</tr>
<tr>
<td>&gt;30 pk/yr</td>
<td>7 (36.8%)</td>
<td>24 (72.7%)</td>
<td></td>
</tr>
</tbody>
</table>

*SD
†Mann-Whitney U-Wilcoxon Rank sum W test.
lower with arm exercise than with treadmill exercise (154.0 ± 15.3 vs 164.4 ± 12.3 beats/min respectively) (p<0.02) (Table 2). The increase in heart rate for arm exercise was also less (73.3 ± 16.0 vs 90.5 ± 15.6 beats/min) (p<0.002) (Table 2). The percent predicted heart rate was significantly lower for arm exercise (85.8 ± 8.7 vs 91.3 ± 6.8 percent) (p<0.02) (Table 2). It has been shown that 75 percent of predicted heart rate is an appropriate level for arm exercise.21

Systolic Blood Pressure

Peak systolic blood pressures during exercise were significantly lower for arm exercise (176.4 ± 19.7 mm Hg vs 194.9 ± 23.0 mm Hg) (p<0.001) (Table 2), but the correlation between arm and leg exercise was good (r = 0.69) (p<0.001).

Pressure Rate Product

At maximal stress, the pressure rate product was significantly lower for arm exercise (273 ± 47 units vs 321 ± 49 units for treadmill exercise) (p<0.001) (Table 2), but there was a good correlation between the pressure rate product for the two forms of exercise (r = 0.68) (p<0.005).

Duration of Exercise

A comparison of the duration of exercise attained during arm and treadmill work was similar (560.6 ± 153.8 seconds for arm exercise vs 559.7 ± 171.1 seconds for treadmill exercise) (Table 2). There was a good correlation between duration of exercise for arm and treadmill methods (r = 0.57) (p<0.05).

Maximal Oxygen Consumption ($V_{O_2} \text{max}$)

Satisfactory results for oxygen consumption for both arm and treadmill exercise were obtained in 15 control subjects. (One healthy subject performed only arm exercise were obtained with O$_2$ consumption and two subjects had no O$_2$ consumption for either arm or treadmill and these three were therefore not included in this determination.) The $V_{O_2}\text{max}$ was significantly lower for arm vs treadmill exercise (25.0 ± 9.7 ml/kg/min vs 34.5 ± 12.4 ml/kg/min respectively) (p<0.001) (Table 2); however, a good correlation between both methods of exercise was observed (r = 0.87) (p<0.001) (Fig 1).

Electrocardiography

None of the control subjects developed electrocardiographic changes during arm exercise; however, during treadmill exercise, one subject had significant ST segment changes.

Comparison of Arm Exercise Data Between Groups 1 and 2

The arm exercise of 17 sedentary control subjects was compared to 32 sedentary subjects with peripheral vascular disease (two subjects in group 1 and one in group 2 were excluded because they were active). Eleven group 2 subjects were unable to increase their

Table 3—Parameters for Arm Exercise in Group 1 and Group 2 Sedentary Subjects

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Subjects</td>
<td>17</td>
<td>32</td>
<td>NS</td>
</tr>
<tr>
<td>Resting HR, beats/min</td>
<td>79.4 ± 17.1*</td>
<td>81.2 ± 15.3</td>
<td>NS</td>
</tr>
<tr>
<td>Maximal HR, beats/min</td>
<td>153.4 ± 15.9</td>
<td>138.2 ± 19.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>HR, beats/min</td>
<td>74.0 ± 16.4</td>
<td>57.0 ± 23.3</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>% Predicted HR</td>
<td>85.6 ± 8.9</td>
<td>77.1 ± 10.7</td>
<td>&lt;0.008</td>
</tr>
<tr>
<td>Resting SBP, mm Hg</td>
<td>120.9 ± 17.8</td>
<td>135.3 ± 13.9</td>
<td>&lt;0.004</td>
</tr>
<tr>
<td>Maximal SBP, mm Hg</td>
<td>175.9 ± 20.3</td>
<td>196.5 ± 31.4</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>SBP, mm Hg</td>
<td>55.0 ± 17.7</td>
<td>61.1 ± 28.4</td>
<td>NS</td>
</tr>
<tr>
<td>PRP max, units</td>
<td>271 ± 49</td>
<td>274 ± 68</td>
<td>NS</td>
</tr>
<tr>
<td>% Predicted PRP</td>
<td>81.6 ± 15.5</td>
<td>83.7 ± 20.8</td>
<td>NS</td>
</tr>
<tr>
<td>$V_{O_2}\text{max}$, ml/kg/min</td>
<td>22.0 ± 4.1</td>
<td>17.9 ± 4.4</td>
<td>(15)*</td>
</tr>
<tr>
<td>Duration of exercise, s</td>
<td>539.2 ± 133.0</td>
<td>485.8 ± 119.4</td>
<td>&lt;0.006</td>
</tr>
<tr>
<td>Work load, kpm/min</td>
<td>520.6 ± 93.6</td>
<td>431.3 ± 106.1</td>
<td>&lt;0.006</td>
</tr>
</tbody>
</table>

*SD,
†Number of subjects.
heart rates to 75 percent of that predicted for their ages. However, all these patients had abnormal ECGs or perfusion defects on myocardial scintigraphy. Standing heart rates at rest were similar in groups 1 and 2 (79.4 ± 17.1 b/min and 81.2 ± 15.3 b/min, respectively) but the heart rates at maximal stress were significantly higher in group 1 (153.4 ± 15.8 b/min) than in group 2 (138.2 ± 19.5 b/min) (p<0.01) (Table 3). The increase in heart rate for the former was also significantly higher (Table 3).

**Exercise Data**

Group 1 was observed to have a longer duration of exercise, higher VO₂max, and achieved a greater maximal work load than group 2 subjects (Table 3). The duration of exercise in group 1 was at least 384 seconds, but eight group 2 subjects (24.2 percent) were only able to exercise for 384 seconds or less. The maximal pressure rate product for both groups was similar because although group 2 had a lower maximal heart rate, the peak systolic blood pressure was higher than for group 1. Work capacity was greater for group 1 than group 2, but this was not statistically significant.

**Electrocardiography**

Only one of the group 1 subjects had electrocardiographic changes (on treadmill only, not on arm exercise) but six group 2 subjects had significant ST segment alterations and one of them developed chest pain with exercise.

**Myocardial Scintigraphy**

Of the 33 group 2 subjects, there were 25 who developed defects on the ²⁰¹Tl scans (75.8 percent). Nine of these 25 patients (36 percent) demonstrated no evidence of reperfusion (consistent with myocardial scars) and two of these nine also had ST segment changes on ECGs. Thirteen men (52 percent) had defects that reperfused (consistent with ischemia) and two of these had abnormal exercise ECGs. Three patients (12 percent) had both reperfused and nonreperfused areas and one had ECG changes as well. Fourteen subjects had inferior, inferoapical, inferoseptal, or inferolateral segments with reperfusion; eight had anteroseptal, septal, or apical, and one a posterior reperfusion defect. Ten inferior, inferoseptal or inferoapical defects did not reperfuse; three septal and two apical defects were fixed. Eight subjects (24.2 percent) had normal ²⁰¹Tl scans, but one had an abnormal exercise ECG.

**Arm Exercise Physiology**

The maximal heart rate, when compared to the VO₂ max for all sedentary subjects in group 1 (15) combined with group 2 (25), showed a good correlation (r = 0.49) (p<0.002). The same was true of the comparison of percent predicted heart rate and VO₂max, (r = 0.45) (p<0.004).

The correlation between the duration of exercise and VO₂ max for both active and sedentary subjects in group 1 (17) combined with group 2 (26) was very high (r = .77) (p<0.001) (Fig 2 c). In fact, the VO₂ max can be derived from duration of exercise by an equation: VO₂ max = 2.28 + .036 (duration of exercise in seconds).

**Echocardiographic Data**

Seventeen group 1 and 30 group 2 subjects had satisfactory quality echocardiograms, and the left ventricular end-diastolic, end-systolic and left atrial dimensions were similar in both groups. The posterior

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Table 4 — Chamber Dimensions, Wall Thickness and Myocardial Function in Group 1 and Group 2 Men

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Subjects</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td>LVDD, mm</td>
<td>46.5 ± 3.7†</td>
<td>45.7 ± 6.0</td>
</tr>
<tr>
<td>LVSD, mm</td>
<td>28.7 ± 3.4</td>
<td>29.6 ± 4.9</td>
</tr>
<tr>
<td>LAD, mm‡</td>
<td>34.1 ± 3.9</td>
<td>34.8 ± 9.6</td>
</tr>
<tr>
<td>PWT, mm</td>
<td>9.1 ± 1.3</td>
<td>10.7 ± 1.6†</td>
</tr>
<tr>
<td>IVST, mm</td>
<td>9.2 ± 1.3</td>
<td>10.7 ± 1.6</td>
</tr>
<tr>
<td>FS, %</td>
<td>38.1 ± 9.6</td>
<td>36.6 ± 6.1</td>
</tr>
</tbody>
</table>

*SD. †FS, fractional shortening; IVST, interventricular septal thickness; LAD, left atrial dimension; and PWT, posterior wall thickness.

wall thickness was less (9.1 ± 1.3 mm) in group 1 than in group 2 (10.7 ± 1.6 mm) (p<0.002) and the septum was thinner in group 1 (9.2 ± 1.3 mm) than in group 2 (10.7 ± 1.6) (p<0.002). Myocardial function noted by percentage fractional shortening was found to be similar.

Of the 33 group 2 patients, six had decreased left ventricular function (<30 percent fractional shortening) and 27 had normal left ventricular function (Table 4).

CLINICAL COURSE

Follow-up data are available for 30 of the 33 patients in group 2 for a period of nine to 29 months. Three patients have developed a typical anginal syndrome: two are receiving medical therapy and one has undergone coronary bypass surgery. (Two of the three patients had positive ECGs and 201Tl scans and one had only a defect on scintigraphy). None of the patients with negative 201Tl studies and ECG findings have developed manifestations of coronary disease. Three other patients have sustained cerebrovascular accidents.

DISCUSSION

The periperooperative and postoperative risk of mortality and morbidity in patients with peripheral vascular disease due to coronary artery pathology has been observed to be of such significance1-5 that presurgical evaluation of the coronary circulation is important in protecting these subjects from cardiac events.

The methodology previously described to detect latent disease has included coronary angiography and such noninvasive studies as radionucleide angiography, dipyridamole with 201Tl,6 combined arm and treadmill exercise, or treadmill testing alone. Since many of these subjects suffer claudication with exertion, arm exercise combined with 201Tl scintigraphy to improve the sensitivity of the test seems an appropriate method of study. Although there are data relating to the physiologic response of normal young adult males and disabled adults with well preserved arm function, there is little information regarding arm exercise physiology in healthy middle-aged and elderly men for comparison with peripheral vascular disease patients. We therefore selected age-matched control subjects to assess their physiologic responses to arm exercise and compared the data to that obtained during conventional treadmill exercise.

The prevalence of abnormal results in our peripheral vascular disease patients substantiates the findings on angiographic examination performed by Hertzler et al.2,3 who noted single vessel disease in 27 percent of patients, two-vessel disease in 19 percent, and three-vessel disease in 11 percent. Thallium-201 scintigraphy revealed perfusion defects in 25 of 33 of our peripheral vascular disease subjects, five of whom had ST segment depressions as well. (One patient with no defects had ECG changes). The physiologic response of the group 2 subjects demonstrated a lower exercise tolerance than that observed in their healthy peers. The minimum duration of exercise in the normal control subjects was 384 seconds but eight group 2 patients exercised for <384 seconds. The work load and the VO2max achieved by the latter group was also significantly less. Eleven males with peripheral vascular disease could not increase their heart rates to 75 percent of that predicted for their age and all had perfusion defects or electrocardiographic changes consistent with ischemia.

A previous study in normal subjects comparing arm and leg exercise utilizing bicycle ergometry demonstrated that peak oxygen uptake was consistently lower in the former than the latter, but a strong correlation between both types of exercise was observed. In patients with ischemic heart disease, the maximal oxygen consumption and work load achieved with leg exercise was greater than when arm exercise was used, but the maximal heart rate and pressure rate product observed was variable. Peak heart rate was lower with arm crank than with treadmill exercise, but systolic blood pressure and pressure rate product were similar. The lower maximal pressure rate product we observed with arm exercise might have resulted in a reduced myocardial oxygen consumption and ischemia monitored by electrocardiography alone might not have become apparent. However, those subjects with positive 201Tl defects and abnormal ECGs did not have a higher pressure rate product.

In our group of healthy subjects, the maximal heart rate, peak systolic blood pressure, peak pressure rate product, and maximal oxygen consumption were all greater with treadmill than with arm exercise. The lower maximal pressure rate product we observed with arm exercise might have resulted in a reduced myocardial oxygen consumption and ischemia monitored electrocardiography alone might not have become apparent. However, those subjects with positive 201Tl
defects and abnormal ECGs did not have a higher PRP max or maximal heart rate than those whose ECGs were negative so this explanation seems unlikely.

Of interest was the observation that duration of arm exercise was so closely correlated with maximal oxygen consumption that the latter could be used to estimate the former by applying the formula: \( \dot{V}O_2 \) max = 2.28 + 0.036 (duration of exercise).

**Limitations**

Coronary arteriography was not performed in this asymptomatic group of patients with peripheral vascular disease. However, our previous study of high risk asymptomatic diabetic patients revealed that on long range follow-up, those with perfusion defects on myocardial scintigraphy were 37 times more likely to develop overt coronary disease and those with electrocardiographic changes were seven times more likely to do so. Furthermore, no subject with negative results on 20T1 and electrocardiography had a coronary event.36

Myocardial scintigraphy was not performed in the normal control subjects. However, in a group of normal males of similar age without signs or symptoms of any arteriosclerotic disease, the prevalence of ischemic changes was low (1/15) and the only abnormal subject had electrocardiographic changes as well as perfusion defects.37

Of the 32 sedentary subjects, only 25 could tolerate exercise with a mouthpiece attachment to monitor oxygen consumption and only 15 sedentary normal men could perform with this device. Patients in this age group, particularly those who are edentulous, may be unable to cooperate. In addition, two patients were unable to perform any arm exercise either due to deconditioning or to possible arteriosclerosis of the arteries supplying the arms.

**Clinical Implications**

Patients with peripheral vascular disease frequently perform poorly when tested with leg exercise either on a bicycle or a treadmill. Arm exercise is therefore a feasible alternative to detect ischemia especially if myocardial scintigraphy is coupled with electrocardiography to improve sensitivity. Patients who are operarative candidates may not require coronary angiography if adequate exercise is performed to increase heart rate (to at least 75 percent of predicted) without ST segment changes or perfusion defects. Alternatively, those subjects who demonstrate ischemia at low levels of exercise may require angiographic study even though vascular surgical intervention is not contemplated.

Finally, the duration of exercise can be utilized to estimate maximal oxygen consumption even in subjects in whom this cannot be obtained directly. Exercise prescriptions for patients in rehabilitation programs which depend on such assessment can be derived by this method.

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