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Comparison of Arm and Treadmill Exercise at 85% Predicted Maximum Heart Rate

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Summary: Both treadmill exercise and arm exercise are used for evaluating coronary artery disease, but arm exercise has lower diagnostic sensitivity. We compared the two exercise modalities with respect to the rate-pressure product at 85% predicted maximal heart rate, a parameter frequently used to denote performance of sufficient exercise to derive clinical conclusions. At this heart rate, treadmill exercise resulted in a significantly greater systemic oxygen consumption ($2.7 \pm .8$ vs. $2.1 \pm .6$ l/min) and rate-pressure product ($30.6 \pm 4.4 \times 10^3$ vs. $28 \pm 3.3 \times 10^3$) than arm ergometry. An inability to generate sufficient imbalance of myocardial oxygen supply and demand may account for the relatively higher incidence of false negative exercise tests seen with arm ergometry, especially if the exercise test is stopped when the patient attains 85% predicted maximal heart rate.

Key words: arm ergometry, treadmill exercise, rate-pressure product

Introduction

Treadmill exercise is a more sensitive test for diagnosis of coronary artery disease than arm exercise.[1] One explanation is that arm exercise does not lead to sufficient increase in myocardial oxygen demand to result in detectable ischemia. In this study we compared the blood pressure response from arm ergometry and treadmill exercise to determine whether a significant difference in myocardial double product exists at 85% predicted maximal heart rate, a parameter commonly used to signify performance of sufficient exercise to derive clinical conclusions.[2]

Methods

The study group consisted of 16 subjects (10 male, 6 female) who volunteered for an investigation of the cardiovascular response to different exercise modalities[3] and were able to exceed 85% predicted maximal heart rate (220-age) during both arm exercise and treadmill exercise. The mean age was 30 ± 2 years. No subject had evidence of cardiovascular disease or was taking medications. Subjects gave signed informed consent approved by the Lenox Hill Hospital Human Investigations Committee.

Each subject performed exercise to volitional fatigue on a motorized treadmill and an arm ergometer. The order of the two tests was assigned randomly, and tests were performed on separate days. Upright arm exercise was performed on a Collins ergometer. The arm exercise protocol consisted of 3 min of exercise, followed by 30 s of rest to permit blood pressure determination. The initial resistance was 25 W, with increments of 25 W for males and 15 W for females. The treadmill exercise protocol also involved 3-min stages, with each stage followed by 30 s of walking at a slow pace (1.7 mph) during which blood pressure was determined. This intermittent design was used to make arm and treadmill protocols similar. Treadmill speed was held constant at 3.5 mph until a 25% grade was achieved in 5% increments, and thereafter speed was increased by 1 mph per stage.

The electrocardiogram (leads II, aVF, V_5) was monitored continuously during exercise and recovery. Blood pressure was obtained by auscultation. Ventilatory gas measurements were made with a SensorMedics metabolic measurement cart (SensorMedics Corp., Anaheim CA) over 15-s intervals during exercise. Oxygen consumption

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and systolic blood pressure at 85% predicted maximal heart rate were determined by using exercise mode-specific regression equations relating each variable to heart rate (r>.9). Values were compared using paired *t*-tests. Group values are reported as mean ± standard error of the mean.

Results

Treadmill exercise resulted in significantly higher peak heart rate (187±3 vs. 174±3 beats/min, p<.01) and measured peak systemic oxygen consumption (3.6±.3 vs. 2.4±.2 l/min, p<.01) compared to arm exercise. The 85% predicted maximal heart rate represented 87±5% of measured peak heart rate during treadmill exercise and 93±5% of measured peak heart rate during arm exercise (p<.01). No subject had angina or significant ST depression during the exercise tests.

The mean systemic oxygen consumption and systolic blood pressure at 85% predicted maximal heart rate during treadmill exercise were significantly higher than that observed during arm ergometry (p<.01) (Table I). With the exception of 2 subjects, the rate-pressure product at 85% predicted maximal heart rate during treadmill exercise was higher than that seen during arm ergometry (p<.01) (Fig. 1).

Discussion

Arm exercise is an alternative method of study for evaluating myocardial ischemia in patients unable to perform treadmill or bicycle exercise. However, arm exercise results in more false negative tests than lower extremity exercise.[1] Our results show that at near peak heart rates arm exercise results in a significantly lower rate-pressure product than leg exercise, providing a possible explanation for reduced sensitivity.

The higher rate-pressure product during treadmill exercise when compared to arm exercise at 85% predicted maximum heart rate results from the blood pressure response at high heart rates. Studies have shown that blood pressure and heart rate are both higher during arm exercise compared to leg exercise at an equivalent external work load.[4,5] However, blood pressure and heart rate during arm and leg exercise increase at a different rate during incremental exercise. While systolic blood pressure is higher during arm than leg exercise at low heart rates, the relationship reverses as maximal heart rates are approached.[5] Consequently, as demonstrated in our study the rate-pressure product is likely to be higher for leg exercise than arm exercise when compared at equal high heart rates.

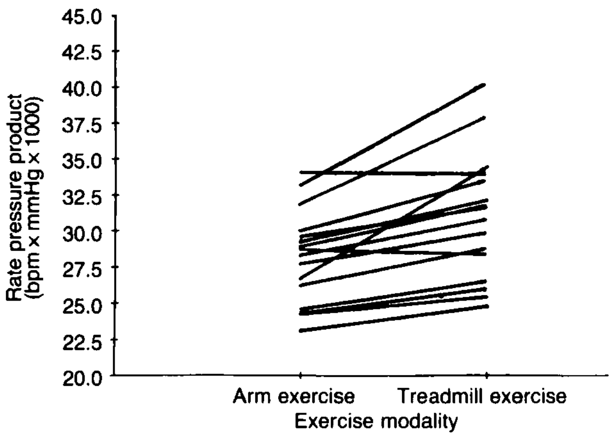

FIG. 1 Comparison of rate-pressure product at 85% age-predicted maximum heart rate during arm exercise and treadmill exercise.

TABLE I Arm vs. treadmill exercise: comparison of systemic oxygen consumption, systolic blood pressure, and rate pressure product at 85% predicted maximum heart rate.

Type of exercise	Arm	Treadmill	p
Heart rate	85% PMHR	85% PMHR	
VO_2	2.1±.2	2.7±.2	<.01
BP	174±5	190±6	<.01
RPP X 10^3	28±1	31±1	<.01

Abbreviations: BP=systolic blood pressure (mmHg); PMHR=predicted maximum heart rate (220-age); RPP=rate pressure product (heart rate X systolic blood pressure); VO_2=systemic oxygen consumption (l/min).

The heart rate corresponding to 85% predicted maximal heart rate was used as the basis for comparison because this parameter is frequently employed as a clinical cutoff during exercise testing. Arm exercise beyond this point may result in a greater rate-pressure product and increased sensitivity, although in this study 85% predicted maximal heart rate corresponded to 93±5% of measured peak heart rate during arm ergometry.

The rate-pressure product was used as an indirect index of myocardial oxygen demand.[6] This parameter does not account for factors such as myocardial contractility and wall tension that contribute to myocardial oxygen consumption. However, Balady *et al.* showed that there was no significant difference between left ventricular contractility or wall stress at a similar rate-pressure product when performing arm ergometry or treadmill exercise.[7]

The results of this study provide a model for further study to understand the different diagnostic sensitivity of various exercise modalities. Patients with coronary artery disease frequently show signs of myocardial ischemia (i.e., angina, electrocardiographic changes) at either the same or at a higher rate-pressure product during arm exercise compared to leg exercise.[1,4,5,8] If the results of our study population are found in patients with coronary disease, the lower rate-pressure product at comparably high heart rates seen during arm ergometry would further increase the likelihood that a subject with coronary artery disease would have a false negative arm exercise test. This is especially important if myocardial ischemia occurs at a high rate-pressure product.

The fact that our subjects were young and had little likelihood of having coronary artery disease is a limitation of the study. Using this protocol, the effect of arm and treadmill exercise in older patients with documented coronary artery disease should be determined. This will help in further understanding the use of different exercise modalities for diagnostic testing.

References

1. Balady GJ, Weiner DA, McCabe CH, Ryan TJ: Value of arm exercise testing in detecting coronary artery disease. *Am J Cardiol* 55, 377 (1985)
2. Selzer A, Cohn K, Goldschlager N: On the interpretation of the exercise test. *Circulation* 58, 193 (1978)
3. Gleim GW, Coplan NL, Scandura M, Holly T, Nicholas JA: Myocardial oxygen demand at equivalent systemic oxygen consumption for 4 different exercise modes. *Med Sci Sports Ex* 18, S82 (1986)
4. Wahren J, Bygdeman S: Onset of angina pectoris in relation to circulatory adaption during arm and leg exercise. *Circulation* 44, 432 (1971)
5. Schwade J, Blomqvist CG, Shapiro W: A comparison of the response to arm and leg work in patients with ischemic heart disease. *Am Heart J* 94, 203 (1977)
6. Kitamura K, Jorgensen CR, Gobel FL, Taylor HL, Wang Y: Hemodynamic correlates of myocardial oxygen consumption during upright exercise. *J Appl Physiol* 32, 516 (1972)
7. Balady GJ, Schick EC, Weiner DA, Ryan T: Comparison on determinants of myocardial oxygen consumption during arm and leg exercise in normal persons. *Am J Cardiol* 57, 1385 (1986)
8. Clausen JP, Trap-Jensen J: Heart rate and arterial blood pressure during exercise in patients with angina pectoris. *Circulation* 53, 436 (1976)