Exercise Stress Testing is Useful, Safe, and Efficient Even in Patients Aged 75 Years or Older

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Objective - *To describe the clinical and hemodynamic variables obtained with exercise testing in elderly patients SW ³ 75 years.*

Methods - *This study assessed 100 patients aged 75-94 years (80±4 years) undergoing symptom-limited exercise testing, 65% of whom were asymptomatic, 25% had nonanginal chest pain, and 10% had typical precordialgia. Of the 100 patients, 32% were males, 50% were hypertensive, 36% were dyslipidemic, 14% were diabetic, and 9% had had previous coronary artery disease. A ramp-adaptation of the Bruce protocol (ramped Bruce protocol) was used, preceded by a 1-minute warm-up with no treadmill incline and a velocity of 1.0 mph.*

Results - *No complications were observed, and 92% of the tests were efficient. On average, the patients reached 95% of the maximum heart rate predicted. The mean duration of the test and the mean metabolic equivalent reached were, respectively, 6.8 ±2 minutes and 6.6 ±2.3 METs. Eleven patients had a hyperreactive inotropic response, and 37% of the sample had noncomplex ventricular and supraventricular arrhythmias. Eighteen percent of the tests were positive for myocardial ischemia. The patients with typical precordialgia had more ischemic responses than did those with nonanginal chest pain or those who were asymptomatic: 70% vs 16% (P<0.001) and 70% vs 10% (P<0.01), respectively.*

Conclusion - *The symptom-limited exercise test is useful, safe, and efficient for analyzing ischemic and hemodynamic responses, even in very elderly individuals.*

Keyword: exercise test, elderly, coronary artery disease

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Coronary artery disease is the major cause of death in the Western world. Although its prevalence increases with age, coronary artery disease may be underdiagnosed. It is detected in only 1.8% of the men and 1.5% of the women above the age of 75 years [1], although an autopsy study of 5,558 patients [2] revealed significant coronary artery disease in 54% of women and 72% of men above the age of 70 years.

Considering the greater prevalence of atypical symptoms and even the absence of precordialgia in the elderly population, the following factors are important for the diagnosis: clinical suspicion in the presence of risk factors and the help of complementary methodologies [3]. Exercise testing is a low-cost examination, easy to perform, and highly reproducible, and, considering our social reality, it has a good cost-risk-benefit ratio even in very elderly patients. However, due to the difficulties of exercise testing in that age group, such as the presence of comorbidities, anxiety about the test, and lack of motivation to undergo it, in addition to lower functional capacity and tolerance for exercising[4], we unfortunately have little data about it in a population above the age of 75 years [5]. This study aimed at assessing the applicability of exercise testing in an elderly population followed up on an outpatient care basis, reporting the clinical and hemodynamic variables obtained, and at comparing the frequency of positive results and the patients' clinical characteristics.

Methods

The population studied comprised patients followed up at the Cardiology and Geriatric Outpatient Care Clinics of the Hospital Guilherme Álvaro of the Medical School of UNILUS, Santos, São Paulo. We consecutively assessed 100 patients, whose ages ranged from 75 to 94 years (mean = 80 ± 4 years), 65% of whom were asymptomatic, 25% had nonanginal chest pain, and 10% had typical precordialgia. They were referred for symptom-limited exercise testing. The sample had the following characteristics: 32% were males, 50% hypertensive, 36% dyslipidemic, 14% diabetics, and 9% had previous coronary artery disease.

The inclusion criteria were as follows: asymptomatic patients, patients with nonanginal chest pain, or with typical coronary artery disease chest pain, aged 75 years or more, consecutively referred for exercise testing. The exclusion criteria were as follows: bedridden patients; no consent; baseline electrocardiographic abnormalities [5,6], such as left bundle-branch block, Wolf-Parkinson-White syndrome, and depression of the ST segment > 1 mm, with conventional contraindications to exercise testing.

A 1-minute warm-up with no treadmill inclination and a velocity of 1.0 mph preceded the Bruce treadmill protocol, which was adjusted with gradual, mild increases in velocity and incline (table I). The test was continuously monitored with 12-lead electrocardiography and CM5, with Ergo PC 13 software for Windows, and blood pressure measurements at rest, every 3 minutes during exercise, at peak effort, and every minute during the recovery period. The test was interrupted for the following reasons: exhaustion; diastolic blood pressure increase (DBP) > 120 mmHg in normotensive patients or > 140 mmHg in hypertensive patients; systolic blood pressure increase (SBP) > 260 mmHg; sustained drop in SBP; clinical manifestation of intense typical precordialgia; depression of the ST segment ≥ 3 mm; elevation in the ST segment ≥ 2 mm in a lead without the presence of the Q wave; complex ventricular arrhythmia; the appearance of sustained supraventricular tachycardia, atrial tachycardia, or atrial fibrillation; 2nd- or 3rd-degree atrioventricular block, signs of left ventricular failure; failure in the monitoring or recording systems, or both. The presence of typical symptoms or symptoms of straightened or descending depression in the ST segment ≥ 1.0 mm or ascending depression of the ST segment ≥ 1.5 mm, 0.08 seconds from the J point, or even an elevation in the ST segment ≥ 1.0 mm, characterized a positive test [5,6]. The test was considered successful if the patient reached at least 85% of the maximum heart rate recommended (220 – age). Hypertension reactive to effort was defined as SBP levels > 220 mmHg or an elevation of 15 mmHg or more in DBP, or both. The indirect measure of maximum oxygen consumption (VO_2max), in METS, was automatically calculated by the software using the formula of the American College of Sports Medicine [7]. The double product was obtained by multiplying the maximum heart rate obtained by the SBP value at peak effort, the patient being allowed to hold the frontal support rails of the treadmill. All medications were suspended for a period equivalent to 5 half-lives before the test.

The Framingham risk was calculated according to the guidelines on dyslipidemias of the Brazilian Society of Cardiology [8].

A retrosternal pain or discomfort in the form of burning, weight, or oppression triggered by effort or emotion, and relieved with rest or nitrates, was considered typical precordialgia. A sharp or ill-characterized chest pain or discomfort, not related to effort, was considered nonanginal chest pain [5].

Statistical analysis was performed with the chi-square test to study the differences in the frequency of positive results for myocardial ischemia among the groups with typical precordialgia, with nonanginal precordialgia, or those who were asymptomatic. In all tests, the rejection level of the null hypothesis was 0.05 or 5% ($\alpha \leq 0.05$). The hemodynamic data were expressed as mean and standard deviation.

Results

No complications were observed during or after the tests, which were efficient in 92% of the patients. On average, the tests ended when 95.7±9.6% of the heart rate predicted for age was achieved. The mean duration of the tests was 6.8±2 minutes, and a double product of 24,945.6±4,576 (bpm x mmHg) and mean metabolic equivalent of 6.6±2.3 METs were reached. A hyperreactive inotropic response was found in 11% of the patients, noncomplex arrhythmias (supraventricular or ventricular extrasystoles) in 37%, and nonsustained ventricular tachycardia in 2% (table II).

Eighteen percent of the tests suggested myocardial ischemia, and most of these patients had chest pain (55.5%) and were at intermediate or high risk for future cardiovascular events (55.5%), according to the Framingham risk score calculated (table III). Patients with typical precordialgia had

Table I - Ramped Bruce protocol. Velocity and incline at every minute

Velocity/Incline	Duration of stage (minutes)	Time accumulated (minutes)
1.0 mph / 0%	1	1
1.0 mph / 7%	1	2
1.5 mph / 8,5%	1	3
1.7 mph / 10%	1	4
2.1 mph / 10%	1	5
2.3 mph / 11%	1	6
2.6 mph / 11,5%	1	7
2.8 mph / 13%	1	8
3.1 mph / 13%	1	9
3.6 mph / 14,5%	1	10
4.2 mph / 16%	1	13

Velocity ratio: 0.26; inclination ratio: 0.75 mph; mph – miles per hour (1 mile = 1.6 km).

Table II - Hemodynamic variables and percentage (%) of the results obtained with exercise testing

Variables	Mean and standard deviation or %
Heart rate at rest (bpm)	82.6 ± 13
Maximum heart rate	134.2 ± 15
(%) of the maximum heart rate reached	95.7 ± 9.6
Double product (bpm x mm Hg)	24945 ± 4576
Duration (minutes)	6.8 ± 2
METs reached	6.6 ±2.3
Positive tests for myocardial ischemia	18%
Hyperreactive inotropic response	11%
Noncomplex arrhythmias	37%
Nonsustained ventricular tachycardia	2%

Bpm - beats per minute; METs - metabolic equivalents (1 MET - oxygen consumption of 3.5 mL/kg/min).

significantly more positive tests than did those with nonanginal chest pain [70% versus 16% (P=0.01)] and also more positive tests than asymptomatic patients had [70% versus 10% (P=0.001)] (figure 1). However, no statistically significant difference was found in the frequency of positive tests among asymptomatic patients and those with nonanginal chest pain [10% versus 16% (P=0.49)].

Discussion

According to data from the last census of the Brazilian Institute of Geography and Statistics (IBGE) [9], Brazil has more than 3.6 million individuals aged 75 years or older, corresponding to 2% of the total population. Although proportionally small, this age group has been increasing in recent years, as has its demand on health care services. In addition, elderly individuals have a greater prevalence of coronary artery disease, which, when present, is more severe than that in younger patients [10]. Exercise testing has a good cost-risk-benefit ratio for diagnosis and prognosis of coronary artery disease, including in the elderly population [11]. However, in a very old population (75 years or more), diseases, such as osteo-articular disorders, previous stroke, chronic obstructive pulmonary disease, and peripheral vasculopathy, frequently coexisting with coronary artery disease, limit the capacity to exercise and may interfere with obtainment of the recommended heart rate. In addition, psychological factors, such as fear, anxiety, and lack of motivation, may interfere with test performance and even with safety [12]. Due to these comorbidities, exercise testing may be neglected by clinicians.

Table III - Distribution of the risk profile for future cardiovascular events according to the clinical indication for exercise testing

Precordialgia/ Risk	High (n / %)	Intermediate	Low	Total
Typical	4 – 66%	–	2 – 34%	6 – 100%
Nonanginal	2 – 50%	–	2 – 50%	4 – 100%
Absent	2 – 25%	2 – 25%	4 – 50%	8 – 100%

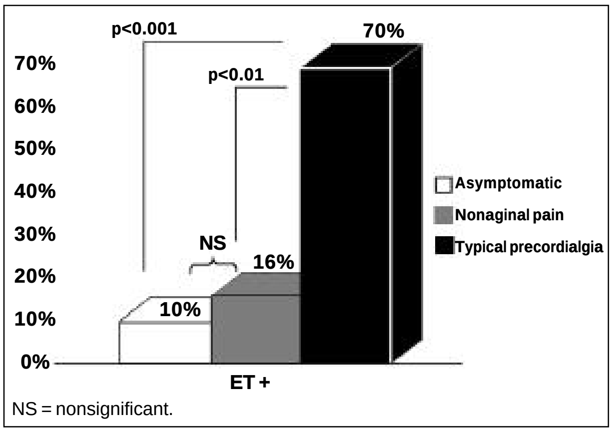

Figure 1 - Percentage of positive tests for myocardial ischemia (ET +) according to the indication for exercise testing: asymptomatic patients, patients with nonanginal pain, or patients with typical precordialgia.

The Bruce protocol was used preceded by a 1-minute warm-up at low velocity and no treadmill inclination based on the 2 following factors: 1) due to the widespread use of Bruce protocol, professionals are acquainted with it; and 2) because tests performed on a ramp last longer and are preferred by elderly patients [13,14]. The elderly usually have a gradual decline in functional capacity, which, even in the absence of comorbidities, may interfere with their tolerance for effort and ability to complete the test. However, with that protocol, we observed that 92% of the patients reached at least 85% of their maximum heart rate, and a mean of 96% of the maximum heart rate predicted for their age. Our results were higher than those obtained in elderly individuals using conventional treadmill protocols, who reached 80% to 84% of the maximum heart rate [13,15]. Kurata et al [16], with a bicycle protocol, reported that, on average, 84% of the maximum heart rate was reached in patients aged 75 to 88 years. Despite the limitations of our population, exercise testing proved to be safe and efficient.

A high frequency of noncomplex arrhythmias was found during exercise testing, especially isolated and monomorphic ventricular and supraventricular extrasystoles. Only 2 episodes of nonsustained ventricular tachycardia occurred at peak effort, with less than 5 beats. Arrhythmias occur more frequently as age increases, mainly during great effort, but they do not necessarily represent adversity, except when accompanied by ischemic responses [17]. The fact that 11% of the patients had hyperreactive inotropic responses may be justified by the high prevalence of hypertensive patients in the sample (50%) associated with the interruption of medications for undergoing the test.

Goraya [11] reported that only the presence of angina during the test and functional capacity were associated with the risk of future cardiovascular events in elderly patients, and that the additional difference of 1 MET accounted for an 18%-reduction in cardiac events and death. This fact stresses the importance of reaching a maximum symptom-limited test, to reliably assess the prognosis of elderly patients. Vivacqua et al [18] studied 1,528 elderly persons undergoing exercise testing, 10% of whom were older than 75 years. Of the latter, 91% reached the maximum recommended heart rate, the mean double product of 23,133 ±3,218 (bpm x mmHg), and the mean metabolic equivalents of 5.6 METs and 5.9 METs, women and men, respectively. In regard to myocardial oxygen consumption on maximum effort, represented by the double product and metabolic equivalents (METs), our results were slightly greater, which may be explained by the difference in the protocols used.

Protocols resulting in short-duration tests cause great discrepancy between oxygen consumption and workload, but, as no evidence exists about the additional benefit of very prolonged exercises, 10 minutes has been suggested as the ideal duration for the test [19]. However, due to the already described comorbidities and difficulties found in the very old population, which may interfere with test performance, the mean duration of our tests was approximately 7 minutes, despite the use of the ramp protocol, providing longer test duration as compared with that of the Bruce protocol [14]. Considering the advanced ages of these patients (mean of 80 years), and the hemodynamic results obtained, we believe that the duration of the tests, coinciding with the conclusion of the second stage of the Bruce protocol, was adequate, efficient testing.

We did not intend to establish sensitivity and specificity in this population, but, based on Bayes theorem, our results were within the expected range. The pretest analysis is fundamental for interpreting the test, requiring knowledge of the clinical history, the risk factors, and especially the characteristics of chest pain. The following parameters are part of Bayes theorem: the probability of an individual having the disease is equal to the pretest probability of the individual versus the probability index of the test being positive [20]. This index depends on the sensitivity and specificity of the test. Most studies available determining the sensitivity and specificity of the test with angiography as the gold standard include very few elderly individuals [21,22]. Vasilomanolaskis et al [23] reported a sensitivity and specificity of 56.2% and 83.7%, respectively, for patients under the age of 40 years, and 84.4% and 70%, respectively, for those over the age of 60 years. Therefore, exercise testing is more sensitive and less specific for detecting coronary atherosclerotic disease in the elderly than in younger persons. Our patients with typical precordialgia had significantly more frequent positive results for myocardial ischemia than did those with nonanginal or asymptomatic chest pain, which is in accordance with results of previous studies [22]. In the elderly, the specificity of the test decreases, due to diseases that affect ventricular compliance, such as arterial hypertension, cardiomyopathies, and valvular diseases, causing electrocardiographic changes at rest, such as depression of the ST segment [11]. However, although more false-positive results are expected, it is worth emphasizing that 25% of the asymptomatic individuals and 50% of those with nonanginal chest pain were considered at high-risk for coronary artery disease, according to the Framingham risk score [8], perhaps justifying the positive results obtained in these groups.

Despite the limitations of exercise testing in a very elderly population, the examination may be considered appropriate and safe. Moreover, within our social context, due to the good cost-risk-benefit ratio of the test, except for its traditional limitations, exercise testing is suitable for a first complementary examination in assessing myocardial ischemia.

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