Effect of body fat on exercise hemodynamics in sedentary older men

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ABSTRACT. Morbid obesity is often associated with cardiac dilatation and left ventricular dysfunction. The present study investigated whether a similar relationship exists between mild and moderate obesity and left ventricular reserve function in 28 middle aged and older men (58.6±6.1 years, mean±SD). Subjects had a body mass index of 26.4±2.9 kg/m², a percent body fat determined by hydrodensitometry ranging from 9.5% to 33.8%, and were carefully screened to exclude cardiovascular disease. Left ventricular function was assessed by gated blood pool scans at rest and during exhaustive upright cycle exercise. There were no significant relationships between resting or exercise cardiac volumes or ejection fraction with percent body fat; however, peak work rate/kg correlated inversely with percent body fat (r=−0.68, p<0.0001). Heart rate reserve, defined as heart rate at peak work rate minus resting heart rate, declined significantly with increasing percent body fat (r=−0.47, p=0.01). End diastolic volume index reserve also tended to decline with increasing percent body fat, but stroke volume index and cardiac index reserve were maintained because the decrease in end systolic volume index from rest to maximal exercise was greatest in those subjects with highest percent body fat (r=−0.41, p=0.03). Therefore, rest and exercise left ventricular function are not related to percent body fat in healthy older men. However, older more obese men have a smaller increase in heart rate and end diastolic volume and a greater decrease in end systolic volume from rest to peak effort as a mechanism to augment exercise cardiac output.

INTRODUCTION

Obesity is often associated with cardiac disease, including hypertension and congestive heart failure (1-4). Patients with massive obesity often have associated left ventricular dilatation and subsequent left ventricular eccentric hypertrophy (5). These adaptive cardiac changes in obese subjects are thought to be related to an increase in circulating blood volume with a subsequent increase in preload (2, 5, 6). An increase in afterload wall stress may also contribute to left ventricular dysfunction in subjects with morbid obesity (5-7). Weight loss is associated with improved left ventricular systolic function, and reduction in left ventricular hypertrophy (7-9).

Previous studies evaluating left ventricular systolic function in obesity included only morbidly obese young patients. Obesity is also an important health problem in middle aged and elderly subjects. The Second National Health and Nutrition Examination Survey found that 26% of U.S. adults, or about 34 million people aged 20 to 75 years, are overweight (10). Secondly, aging inter alia is associated with changes in resting and exercise cardiac function (11, 12), which may influence the

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cardiovascular adaptations to obesity. Finally, the elderly population often has left ventricular dysfunction from underlying coronary artery disease and hypertension. Therefore, it would be valuable to identify a potentially reversible cause (i.e., obesity modifiable by weight loss) of left ventricular dysfunction in this age group. The purpose of the current study was to evaluate the relationships between rest and exercise cardiac function and percent body fat in a group of middle aged and elderly subjects with mild and moderate obesity who were carefully screened to exclude underlying cardiovascular disease.

METHODS

Subjects

Male volunteers over age 45 were recruited from the Baltimore-Washington area through advertisements in local newspapers, public service announcements on radio and television, and visits to senior citizen centers, for participation in the Fitness after Forty-Five program (12). All gave written informed consent, and the protocol was approved by the hospital’s Joint Committee on Clinical Investigation. Subjects were screened over the telephone and subsequently through a detailed medical history questionnaire, and were excluded for the following conditions: (a) smoking or pulmonary disease; (b) any cardiovascular disease including a history of cardiac arrhythmias, angina pectoris, congestive heart failure, valvular heart disease, or prior myocardial infarction; (c) peripheral or cerebral vascular disease; (d) hypertension, blood pressure >140/90 mmHg; (e) diabetes or hyperlipidemia, or any disease or medication which would affect glucose or lipid metabolism; (f) chronic alcoholism or average daily consumption greater than 3 ounces of alcohol; (g) any significant orthopedic condition which would interfere with exercise testing; (h) neurologic or psychiatric disease; or (i) any other medical or physical condition which could prevent the subject from completing an exercise and/or weight loss intervention study. The subjects found eligible at this point underwent further testing, including a physical examination, and laboratory blood studies including fasting lipids, glucose, electrolytes, liver function, renal function and complete blood count. Pulmonary function tests and a submaximal treadmill exercise test were also performed as a screening procedure. Subjects were excluded if evidence of the previously described medical conditions was found on physical examination or laboratory blood tests, or if their forced vital capacity or their forced expiratory volume / forced vital capacity ratio was less than 70% predicted. Subjects who displayed ischemic treadmill exercise test results, or who were unable to complete 6-8 minutes of the modified Bruce protocol, or achieve a heart rate (HR) of ≥85% of age-predicted maximum (220 - age) were also excluded from participation.

The subjects who qualified for the program underwent several weeks of baseline testing which included (a) a minimum of two treadmill exercise tests for measurement of maximal oxygen consumption (VO2max), (b) measurements of body composition by hydrodensitometry, and (c) gated blood pool scans. Body mass index (BMI) was calculated as weight (kg) divided by height (m)². Body surface area (BSA) is (weight0.425 x height0.725 x 0.007184). Body density was determined by hydrodensitometry with a correction for residual lung volume. Each subject repeated the underwater weighing maneuver 7 to 10 times until a stable underwater weight was achieved (13). Percent body fat (PBF) was calculated from body density using the Siri equation (14).

Gated blood pool scans

Gated blood pool scans were obtained after blood pool equilibrium of red cells labeled with technetium-99m (12 MCI/M²), as previously described (15). The camera was positioned to best define the ventricular septum, usually the 40° left anterior oblique view. Images were obtained for cardiac volumes and ejection fraction with the subject at rest in the supine position, at rest 15 minutes after sitting in the upright position, and during maximal upright cycle exercise. Images were acquired with a high-sensitivity, parallel-hole collimator attached to a standard Anger camera interfaced with a commercial nuclear medicine computer system. Exercise was begun on an electronically-braked cycle ergometer at 25 watt work rate and increased in increments of 25 watts every 3 minutes until exhaustion. Images were acquired during the last 2.5 minutes of each period. Systolic and diastolic blood pressures (SBP and DBP respectively) were measured.