Relation of Body's Lean Mass, Fat Mass, and Body Mass Index With Submaximal Systolic Blood Pressure in Young Adult Men

Vivek K. Prasad, MD, MPH, PhD[a,*], Clemens Drenowatz, PhD[a], Gregory A. Hand, PhD[b], Carl J. Lavie, MD[c], Xuemei Sui, MD, MPH, PhD[a], Madison Demello, MS[a], and Steven N. Blair, PED[a,d]

We examined the association of body composition and body mass index (BMI) with submaximal systolic blood pressure (SSBP) among young adult men. The analysis included 211 men with BMI between 20 and 35 kg/m^2. Total lean mass and fat mass were measured using dual x-ray absorptiometry and lean mass percentage was calculated from the total lean mass. Fat mass index (FMI) and BMI were calculated using height and weight (total fat mass and total weight, respectively) measurements. SSBP was measured at each stage of a graded exercise test. Quintiles of lean mass percentage, FMI, and BMI were created with quintile 1 the lowest and quintile 5 the highest lean mass percentage, FMI, and BMI. Compared with men in lean mass percentage quintile 1, those in quintiles 2, 3, and 4 had significantly lower SSBP, whereas there was no significant difference in SSBP between quintile 1 and 5 at 6, 8, and 10 minutes. Compared with men in FMI quintile 5, those in quintiles 2, 3, and 4 had significantly lower SSBP, whereas there was no significant difference in SSBP between quintile 1 and 5. SSBP among men in lean mass percentage quintile 5 and FMI quintile 1 were still less than lean mass percentage quintile 1 and FMI quintile 5, respectively. There were no significant differences in SSBP across BMI quintiles 1 to 4 but a significantly higher SSBP in quintile 5 compared with quintiles 1 to 4. In conclusion, there was a J-curve pattern between SSBP and components of body composition, whereas, a linear relation between SSBP and BMI. **(Am J Cardiol 2016;117:394–398)**

Body composition and body mass index (BMI) are known predictors of cardiovascular disease risk factors,[1] morbidity, and mortality.[2,3] Studies investigating relations of submaximal systolic blood pressure (SSBP) with body composition and BMI have reported different trends, with one study suggesting that high BMI at baseline is associated with lower SSBP after 7 years in middle-aged (40 to 59 years) healthy men.[4] Another study reported that decrease in body fat is associated with lower SSBP in older adults.[5] To the best of our knowledge, there is no study examining the association of SSBP with body composition and BMI in young healthy men. Therefore, we analyzed the relation between SSBP and various indicators of weight and how this relation differs in case of BMI compared to body composition.

Methods

The study recruited 211 men aged 21 to 35 years with a BMI between 20 and 35 kg/m^2. Participants were excluded if they had (1) a change in smoking status in the previous 6 months; (2) used medications to lose weight; (3) planned a weight loss surgery; (4) blood pressure (BP) at rest >150 mm Hg systolic and/or 90 mm Hg diastolic; (5) an ambulatory blood glucose level of >145 mg/dl; (6) been diagnosed with/or taking medications for a major chronic health condition; or (7) a history of anxiety, depression, or panic attack or taking selective serotonin inhibitors for any reason.[6]

Anthropometric measurements were performed with the men wearing basic medical scrubs and in bare feet. Height (cm) and weight (kg) were measured to the nearest 0.1 cm and 0.1 kg, respectively, and BMI (kg/m^2) was calculated. Lean mass and fat mass were measured using a dual x-ray absorptiometry. Subsequently, lean mass percentage and fat mass index (FMI, kg/m^2) were calculated.

SSBP, submaximal heart rate, and cardiorespiratory fitness (CRF) defined as peak oxygen consumption (VO_2) were measured using a treadmill-based graded exercise test (GXT) administered by a trained exercise physiologist. The subject was instructed to rest their left arm on the shoulder of the staff member pretest and during each stage of GXT. They were also instructed to avoid gripping the shoulder of the staff member and getting an external support while walking or running during the GXT. After measurement of pre-exercise BP and heart rate, the GXT was administered using a modified Bruce protocol, which starts at a grade of 0% at 1.7 mph for initial 2 minutes and progresses to 5%

Departments of [a]Exercise Science and [d]Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina; [b]School of Public Health, Robert C. Byrd Health Sciences Center, West Virginia University, Morgantown, West Virginia; and [c]Department of Cardiovascular Diseases, John Ochsner Heart and Vascular Institute, Ochsner Clinical School, The University of Queensland School of Medicine, New Orleans, Louisiana. Manuscript received August 1, 2015; revised manuscript received and accepted October 30, 2015.

This project was provided through an unrestricted grant from the Coca-Cola Company, Atlanta, Georgia. The sponsor played no role in the study design, data collection, analysis, and interpretation, or preparation and submission of this manuscript.

See page 397 for disclosure information.

*Corresponding author: Tel/fax: (+1) 8035538725.

E-mail address: prasadv@email.sc.edu (V.K. Prasad).

0002-9149/15/$ - see front matter
http://dx.doi.org/10.1016/j.amjcard.2015.10.060

Table 1
Descriptive characteristics across the quintiles of lean mass percentage, fat mass index, and body mass index

Lean mass % quintiles	Quintile 1 (N=42)	Quintile 2 (N=42)	Quintile 3 (N=43)	Quintile 3 (N=42)	Quintile 5 (N=42)	P value*
Age, mean (SD), (years)	28.6 (3.3)	28.7 (3.8)	27.2 (3.8)	26.7 (3.6)	26.2 (4.2)	0.005
Whites	32 (76%)	22 (52%)	33 (77%)	27 (64%)	29 (69%)	0.12
Systolic blood pressure, mean (SD), (mmHg)	127.3 (10.9)	127.7 (11.2)	124.0 (11.0)	126.0 (10.6)	128.4 (12.1)	0.4
Body mass index, mean (SD), (kg/m^2)	29.9 (2.9)	26.2 (2.9)	24.6 (2.1)	24.2 (2.2)	23.6 (2.3)	<0.001
Lean mass, % (SD)	67.0 (3.1)	73.3 (1.3)	78.4 (1.6)	83.1 (1.1)	88.2 (2.1)	<0.001
Fat mass index, mean (SD), (kg/m^2)	9.8 (1.5)	7.0 (0.7)	5.4 (0.6)	4.3 (0.5)	3.1 (0.6)	<0.001
Alcohol intake, mean (SD), (g/d)	9.7 (29.0)	10.7 (17.9)	15.1 (20.0)	14.2 (20.8)	14.8 (26.1)	0.74
Vo2 peak mean (SD), (ml/kg/min)	35.7 (5.9)	40.3 (6.4)	45.5 (6.3)	47.5 (6.2)	50.3 (7.3)	<0.001
Ever smoked	13 (31%)	12 (29%)	14 (33%)	10 (24%)	11 (26%)	0.9
Fat mass index quintiles	(N=41)	(N=43)	(N=42)	(N=43)	(N=42)	
Age, mean (SD), (years)	26.1 (4.0)	26.9 (3.8)	26.9 (3.6)	29.0 (3.9)	28.6 (3.3)	0.001
Whites	30 (71%)	30 (70%)	27 (64%)	26 (61%)	31 (74%)	0.44
Systolic blood pressure, mean (SD), (mmHg)	128.0 (12.2)	125.9 (11.0)	124.6 (10.9)	126.3 (10.4)	128.8 (11.3)	0.44
Body mass index, mean (SD), (kg/m^2)	23.5 (2.6)	23.8 (1.9)	24.7 (2.1)	26.1 (2.3)	30.6 (2.2)	<0.001
Fat mass index, mean (SD), (kg/m^2)	2.9 (0.6)	4.3 (0.4)	5.4 (0.3)	7.0 (0.5)	9.9 (1.4)	<0.001
Lean mass, % (SD)	88.2 (2.3)	82.9 (1.9)	78.6 (2.4)	73.2 (2.2)	67.5 (3.6)	<0.001
Alcohol intake, mean (SD), (g/d)	14.7 (26.4)	16.1 (20.9)	14.1 (20.1)	9.4 (16.3)	11.1 (30.1)	0.66
Vo2 peak mean (SD), (ml/kg/min)	50.5 (7.7)	48.1 (6.3)	44.3 (5.5)	40.8 (6.7)	35.7 (5.4)	<0.001
Ever smoked	10 (24%)	10 (23%)	16 (38%)	10 (23%)	14 (33%)	0.4
Body mass index quintiles	(N=42)	(N=42)	(N=40)	(N=45)	(N=42)	
Age, mean (SD), (years)	25.5 (3.2)	27.0 (3.5)	27.9 (4.1)	28.2 (4.3)	28.8 (3.3)	<0.001
White	26 (62%)	32 (76%)	24 (60%)	28 (62%)	34 (79%)	0.2
Systolic blood pressure, mean (SD), mmHg	123.4 (12.6)	124.7 (10.4)	126.5 (10.5)	127.2 (10.3)	131.5 (10.6)	0.009
Lean mass, % (SD)	83.3 (5.0)	81.1 (6.8)	78.5 (5.6)	78.0 (6.3)	69.2 (6.1)	<0.001
Body mass index, mean (SD)	21.4 (1.0)	23.5 (0.5)	24.9 (0.6)	26.6 (0.8)	30.7 (1.8)	<0.001
Fat mass index, mean (SD)	2.9 (0.6)	4.3 (0.4)	5.4 (0.3)	7.0 (0.5)	9.9 (1.4)	<0.001
Alcohol intake, mean (SD), (g/d)	11.2 (19.4)	15.7 (26.0)	13.1 (19.9)	11.2 (17.8)	14.3 (30.8)	0.34
Vo2 peak mean (SD), (ml/kg/min)	47.2 (8.0)	46.8 (8.0)	45.0 (7.6)	43.6 (7.5)	36.9 (5.7)	<0.001
Ever smoked	9 (21%)	15 (36%)	9 (29%)	14 (31%)	13 (30%)	0.54

* p Value for quadratic trend.

grade at the same speed for next 2 minutes. After 4 minutes, the protocol is similar to that of the Bruce protocol. The speed and grade at time points 6, 8, and 10 minutes of GXT were 1.7 mph, 10%; 2.5 mph, 12%; and 3.4 mph, 14%, respectively. All men exercised to volitional fatigue and indicated when to stop. The test followed continued walking at 1.7 mph and 0% grade until their BP returned to near baseline level and heart rate $\leq$120. SSBP and submaximal heart rate were recorded at the second minute of each stage of the GXT by a trained staff member.

Systolic BP (SBP) was measured twice in the seated position by a well-trained technician using a mercury sphygmomanometer. The average of 2 readings was used for the representative examination value. A third measurement was taken if the difference in SBP at rest was >10 mm Hg. In addition, alcohol consumption was determined using multiple, telephone-administered, 24-hour dietary recall interviews, and smoking history was self-reported through a personal medical history questionnaire.

Quintiles of lean mass percentage, FMI, and BMI were established with quintile 1 representing the groups of men with the lowest lean mass percentage, FMI, and BMI, whereas quintile 5 represented those with the highest lean mass percentage, FMI, and BMI. One way analysis of variance was used to determine the descriptive means across all the quintiles of lean mass percentage, FMI, and BMI. The chi-square test was used to determine differences in ethnicity and smoking status in quintiles. Multivariate and univariate analysis including potential covariates including age, race, SBP at rest, alcohol intake, smoking history, and CRF were done to determine the association between SSBP at 6, 8 and 10 minutes of GXT and quintiles of lean mass percentage, FMI, and BMI. All analyses were done using SPSS (version 22) with $p < 0.05$ for statistical significance.

A small amount of data (9%) were excluded from the current analysis because of missing SSBP or covariates. The missing SSBP data were mainly due to failure in the measurement of SSBP during the GXT when the staff member was unable to hear the Korotkoff sounds accurately during BP measurement. Nevertheless, the characteristics of men who were excluded had no significant difference ($p \geq 0.05$) compared with those in the analysis.

Results

Table 1 lists the descriptive characteristics of men across the quintiles of lean mass percentage, FMI, and BMI. BMI quintiles 1 and 2 represent normal BMI range, quintiles 3 and 4 overweight, and quintile 5 obese. Categorizing the mean VO_2 peak according to the American College of