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Association of Obesity in Early Adulthood and Middle Age With Incipient Left Ventricular Dysfunction and Structural Remodeling

The CARDIA Study (Coronary Artery Risk Development in Young Adults)

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ABSTRACT

OBJECTIVES The goal of this study was to investigate the relationship of body mass index (BMI) and its 25-year change to left ventricular (LV) structure and function.

BACKGROUND Longstanding obesity may be associated with clinical cardiac dysfunction and heart failure. Whether obesity relates to cardiac dysfunction during young adulthood and middle age has not been investigated.

METHODS The CARDIA (Coronary Artery Risk Development in Young Adult) study enrolled white and black adults ages 18 to 30 years in 1985 to 1986 (Year-0). At Year-25, cardiac function was assessed by conventional echocardiography, tissue Doppler imaging (TDI), and speckle tracking echocardiography (STE). Twenty-five-year change in BMI (classified as low: <27 kg/m^2 and high: ≥ 27 kg/m^2) was categorized into 4 groups (Low-Low, High-Low, Low-High, and High-High). Multiple linear regression was used to quantify the association between categorical changes in BMI (Low-Low as reference) with LV structural and functional parameters obtained in middle age, adjusting for baseline and 25-year change in risk factors.

RESULTS The mean BMI was 24.4 kg/m^2 in 3,265 participants included at Year-0. Change in BMI adjusted for risk factors was directly associated with incipient myocardial systolic dysfunction assessed by STE (High-High: β-coefficient = 0.67; Low-High: β-coefficient = 0.35 for longitudinal peak systolic strain) and diastolic dysfunction assessed by TDI (High-High: β-coefficient = −074; Low-High: β-coefficient = −0.45 for e′) and STE (High-High: β-coefficient = −0.06 for circumferential early diastolic strain rate). Greater BMI was also significantly associated with increased LV mass/height (High-High: β-coefficient = 26.11; Low-High: β-coefficient = 11.87).

CONCLUSIONS Longstanding obesity from young adulthood to middle age is associated with impaired LV systolic and diastolic function assessed by conventional echocardiography, TDI, and STE in a large biracial cohort of adults age 43 to 55 years. (J Am Coll Cardiol HF 2014;2:500–8) © 2014 by the American College of Cardiology Foundation.

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Longstanding obesity is strongly related to a higher prevalence of clinical heart failure; in most studies, left ventricular (LV) function is assessed by echocardiographic left ventricular ejection fraction (LVEF) (1,2). Obesity has also been associated with adverse LV remodeling and impaired LV diastolic function (2–4); however, although current cross-sectional epidemiological studies do not show an inverse relationship between LVEF and obesity (3), a higher body mass index (BMI) has been associated with more subtle markers of LV dysfunction determined by echocardiography (5). Moreover, the effects of obesity on myocardial deformation during contraction and relaxation have not been investigated among young adults who may be more malleable to lifestyle modification, and may be at greater lifetime risk for developing heart failure.

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LV functional mechanics are complex. LV motion includes longitudinal and circumferential shortening, with radial thickening and cardiac rotation and torsion along the LV long axis. In this regard, myocardial strain is a measure of such myocardial deformation expressed as a fractional or percentage change from an object's original dimension (6). Two-dimensional (2D) speckle tracking echocardiography (STE) is an angle-independent method for deformation assessment that enables strain measurement in the longitudinal, circumferential, and radial directions based on conventional echocardiographic images. Moreover, to assess early changes in diastolic function, tissue Doppler imaging (TDI) takes advantage of the exceptional temporal resolution provided by echocardiography, and is considered the reference method (7). When compared with traditional echocardiographic measurements such as LVEF, myocardial deformation parameters assessed by STE represent earlier indicators of cardiac dysfunction (8).

We hypothesized that higher BMI measured during young adulthood (ages 18 to 30 years) predicts decreased LV function and cardiac remodeling 25 years later. We focused the analysis on the relative associations between young adulthood BMI measured at the CARDIA (Coronary Artery Risk Development in Young Adults) study baseline examination (Year-0), and the 25-year change in BMI with cardiac structure and function measured in mid-life. In addition to the conventional echocardiographic measurements, we investigated how BMI that was measured during young adulthood, as well as the difference in BMI between young adulthood and middle age (ages 43 to 55 years), relates to LV systolic and diastolic deformation assessed as myocardial strain measured by STE, as well as by TDI and conventional echocardiography.

METHODS

PARTICIPANTS. The CARDIA study is a multicenter prospective study that enrolled 5,115 white and black men and women from 4 U.S. Field Centers (Birmingham, Alabama; Oakland, California; Chicago, Illinois; and Minneapolis, Minnesota) in 1985 to 1986 (Year-0) and followed them prospectively at 7 subsequent time periods. Of 3,498 participants attending the Year-25 (2010 to 2011) examination, representing 72.0% of the surviving cohort, 3,474 participants (99.3%) underwent standard echocardiography and STE assessment at Year-25. We excluded participants that were pregnant ($n = 8$) or missing a covariate ($n = 201$) at the Year-0 or Year-25 examinations. The remaining 3,265 participants (94.0%) were included in the current analyses.

COVARIATES. Standardized protocols were used to measure height, weight, heart rate, blood pressure, lipids, glucose, smoking, educational level, and physical activity (9,10). Information on demographic characteristics, alcohol use (ml/day), smoking status (number of cigarettes/day), educational level (years), physical activity score, and medication use was collected by interview. BMI was calculated as weight (kg) divided by height in meters squared (m^2). Regarding weight status categories, normal weight was defined as BMI between 18.5 and 25.0 kg/m^2, overweight as BMI between 25 and 30 kg/m^2, and obese as BMI $\geq$30 kg/m^2. Alternative categories investigated were high BMI ($\geq$27 kg/m^2) and low BMI (<27 kg/m^2). The difference in BMI from Year-0 to Year-25 was categorized into 4 groups: 1) high BMI at Year-0 and high BMI at Year-25 (High-High); 2) low BMI at Year-0 and high BMI at Year-25 (Low-High); 3) high BMI at Year-0 and low BMI at Year-25 (High-Low); and 4) low BMI at Year-0 and low BMI at Year-25 (Low-Low). After a 5-min rest, blood pressure was measured 3 times with a random-zero sphygmomanometer and the last 2 values averaged; resting heart rate was also measured. The presence of diabetes was assessed at each examination based on a combination of medication use questions, fasting plasma glucose $\geq$126 mg/dl (Year-0 and Year-25), 2-h glucose $\geq$200 mg/dl (Year-25), or HbA_{1c} $\geq$6.5%

ABBREVIATIONS AND ACRONYMS

2D = 2-dimensional

A = late peak diastolic mitral flow velocity

BMI = body mass index

E = early peak diastolic mitral velocity

e′ = peak early diastolic mitral annular velocity

Ecc = circumferential peak strain

Ecc_SRe = circumferential peak early diastolic strain rate

Ell = 4-chamber longitudinal peak strain

Ell_SRe = 4-chamber longitudinal peak early diastolic strain rate

LAV = left atrial volume

LV = left ventricular

LVEDV = left ventricular end-diastolic volume

LVEF = left ventricular ejection fraction

LVESV = left ventricular end-systolic volume

LVM = left ventricular mass

LVSV = left ventricular stroke volume

STE = speckle tracking echocardiography

TDI = tissue Doppler imaging