Metabolic Syndrome, Strain, and Reduced Myocardial Function: Multi-Ethnic Study of Atherosclerosis

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Abstract

Background: Subclinical cardiovascular disease is prevalent in patients with Metabolic Syndrome (MetSyn). Left ventricular (LV) circumferential strain (ε_{CC}) and longitudinal strain (ε_{LL}), assessed by Speckle Tracking Echocardiography (STE), are indices of systolic function: shortening is indicated by negative strain, and thus, the more negative the strain, the better the LV systolic function. They have been used to demonstrate subclinical ventricular dysfunction in several clinical disorders.

Objective: We hypothesized that MetSyn is associated with impaired myocardial function, as assessed by STE.

Methods: We analyzed Multi-Ethnic Study of Atherosclerosis (MESA) participants who underwent STE and were evaluated for all MetSyn components.

Results: Among the 133 participants included [women: 63%; age: 65 ± 9 years (mean ± SD)], the prevalence of MetSyn was 31% (41/133). Individuals with MetSyn had lower ε_{CC} and lower ε_{LL} than those without MetSyn (-16.3% ± 3.5% vs. -18.4% ± 3.7%, p < 0.01; and -12.1% ± 2.5% vs. -13.9% ± 2.3%, p < 0.01, respectively). The LV ejection fraction (LVEF) was similar in both groups (p = 0.09). In multivariate analysis, MetSyn was associated with less circumferential myocardial shortening as indicated by less negative ε_{CC} (B = 2.1%, 95% CI: 0.6-3.5, p < 0.01) even after adjusting for age, ethnicity, LV mass, and LVEF). Likewise, presence of MetSyn (B = 1.3%, 95% CI: 0.3-2.2, p < 0.01) and LV mass (B = 0.02%, 95% CI: 0.01-0.03, p = 0.02) were significantly associated with less longitudinal myocardial shortening as indicated by less negative ε_{LL} after adjustment for ethnicity, LVEF, and creatinine.

Conclusion: Left ventricular ε_{CC} and ε_{LL}, markers of subclinical cardiovascular disease, are impaired in asymptomatic individuals with MetSyn and no history of myocardial infarction, heart failure, and/or LVEF < 50%. (Arq Bras Cardiol. 2014; 102(4):327-335)

Keywords: Atherosclerosis; Metabolic X Syndrome; Diabetes Mellitus / mortality; Ventricular Dysfunction / physiopathology; Ethnic Group.

Introduction

Metabolic syndrome (MetSyn) is characterized by a cluster of cardiovascular (CV) risk factors including atherogenic dyslipidemia, abdominal obesity, hyperglycemia, elevated blood pressure, and proinflammatory and prothrombotic state[1]. It affects about 25% of the population, being associated with an increased risk of developing diabetes, CV morbidity and mortality[2].

Previous studies using carotid intima-media thickness measured with ultrasound, coronary artery calcium, Tei index, and tissue Doppler have shown the presence of subclinical CV disease (CVD) in participants with MetSyn[3-13].

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Recently, speckle tracking echocardiography (STE) has been introduced as a new non-invasive method for assessing left ventricular (LV) myocardial shortening or strain. The method is angle-independent, does not require contrast agents, and has been validated against sonomicrometry and magnetic resonance imaging (MRI)[14-17]. It has been used to demonstrate subclinical ventricular dysfunction in various clinical disorders[18-22].

The purpose of this study was to evaluate the use of STE to assess myocardial strain as a marker of LV systolic function in an asymptomatic population with MetSyn and LV ejection fraction (LVEF) ≥ 50%. We hypothesized that MetSyn is associated with impaired LV circumferential strain (ε_{CC}), as well as with LV longitudinal strain (ε_{LL}).

Methods

Study population

The purpose of the Multi-Ethnic Study of Atherosclerosis (MESA), a multicenter population-based study, is to investigate mechanisms underlying the development and

progression of subclinical CVD in asymptomatic men and women from four different ethnic groups – Caucasian, African-American, Hispanic, and Chinese[23]. Between July/2008 and June/2009, during MESA follow-up evaluation, 162 consecutive participants in the Baltimore cohort of MESA were invited to undergo an echocardiographic study. We included participants who underwent echocardiography, tagged MRI (reference method for ε_{cc}), and evaluation for all MetSyn components. Participants who had more than two LV segments not analyzable on STE in short-axis- or 4-chamber view were excluded from the strain analysis. Exclusion criteria also included a history of myocardial infarction (MI), heart failure (HF) and/or LVEF < 50%. The institutional review board of the Johns Hopkins University approved the study, and participants provided written informed consent.

Metabolic syndrome definition

Metabolic syndrome was defined according to revised National Cholesterol Education Program Adult Treatment Panel (NCEP ATP) III criteria[24]. Participants having at least three of the following criteria were considered as having MetSyn: fasting plasma glucose (FPG) ≥ 100 mg/dL; triglycerides ≥ 150 mg/dL; HDL-cholesterol < 40 mg/dL in men and < 50 mg/dL in women; abdominal obesity [waist circumference (WC) ≥ 102 cm in men and ≥ 88 cm in women]; and blood pressure ≥ 130/85 mm Hg. The revised NCEP definition still includes patients being treated for dyslipidemia, systemic hypertension, or hyperglycemia.

Risk factors

Participants completed standardized medical history questionnaires ascertaining medication use and previous diagnoses and provided samples for quantification of FPG, lipids, and creatinine[25]. Waist circumference was measured at the level of the umbilicus using a standard tape measure. Resting blood pressure was measured three times in a seated position using a Dinamap model Pro 100 automated oscillometric sphygmomanometer (Critikon, Tampa, FL, USA). The average of the last two measurements was used in the analysis. Arterial hypertension was diagnosed using the VII Joint National Committee criteria[26]. Diabetes was defined as a FPG ≥126 g/mL or use of insulin or of an oral hypoglycemic agent. Smoking status was defined as current smoking or no smoking.

Echocardiography and speckle tracking

Examinations were performed by expert sonographers, and reviewed off-line by one reader (ALCA). Two-dimensional echocardiograms were recorded during breath-holds using an Artida scanner (Toshiba Medical Systems Corp, Tochigi, Japan) at the time of MESA follow-up evaluation. The images were acquired from the short-axis view of the left ventricle at the papillary muscle level and from the apical 4-chamber view, and stored digitally. The images were recorded using B-mode harmonic images and adjusting transducer frequencies (1.7-3.5 MHz), frame rate (40-80 frames per second), focus (midventricular), sector width (as narrow as possible), sector depth (minimal) and gain in order to optimize myocardial image quality. The echocardiographic recordings were analyzed with STE software (Toshiba 2D Wall Motion Tracking software, Toshiba Medical Systems). The manual counterclockwise tracing of endocardial and epicardial borders in the mid-LV short-axis image at end-systole was followed by automatic drawing of a mid-wall tracking line[14]. A similar approach was made in the 4-chamber recording, starting at the lateral corner of the mitral annulus, at the end-diastole. STE software uses the 'sum of squared differences' method to find the most similar speckle pattern of the 2D template in two subsequent frames[27]. Strain (ε, %) was calculated as the change in regional length relative to its end-diastolic length; $\varepsilon = (L_{(t)} - L_0)x100/L_0$, where $L_{(t)}$ is the length at time t, and L_0 is the segment length at the onset of QRS. Global ε_{CC} (Figure 1) and ε_{LL} (Figure 2) are represented by the peak of average strain. As ε reflects myocardial shortening, a more negative value indicates more shortening. The mid-ventricular short axis level and the 4-chamber view of the left ventricle were divided according to the American Society of Echocardiography recommendation[28]. Segments were excluded from analyses due to dropouts, motion artifacts, reverberations, or bad tracking quality due to manual assessment.

Magnetic Resonance Imaging: Tagged MRI protocol and strain measurement

Participants underwent MRI and echocardiography on the same day. Cardiac MRI scan was acquired using 1.5T MR scanners [Signa LX or CVi (GE Medical Systems, Waukesha, WI, USA)]. Images were obtained using a segmented k-space and ECG-triggered SPGR pulse sequence. After acquisition of standard scout images, 2- and 4-chamber cine MR images were acquired. Short-axis cine images were then obtained with retrospective gating and temporal resolution of ≤ 50 msec, from above the mitral valve plane to the LV apex[29]. Left ventricular structural parameters (end-systolic and end-diastolic volumes, LV mass) and LVEF were measured using standard commercially available software (MASS 4.2, MEDIS, Leiden, The Netherlands), as previously described[29]. Left ventricular mass index was defined as LV mass divided by body surface area. After completing the standard protocol, three tagged short-axis slices (base to apex) were obtained. Parallel striped tags were prescribed in two orthogonal orientations (0° and 90°) using ECG-triggered fast gradient echo sequence with spatial modulation of magnetization. The parameters for tagged images were as follows: field of view, 40 cm; slice thickness, 7 to 8 mm; repetition time, 6 ms; echo time, 3.0 ms; flip angle, 10° to 12°; phase encoding views, 128 with six phase encoding views per segment; temporal resolution, 35 msec; and tag spacing, 7 mm. Circumferential strain was measured using HARP method embedded in MATLAB software (The MathWorks, Natick, MA, USA)[30].

Reproducibility

Thirty studies were randomly selected for the assessment of intra- and inter-observer variability of ε_{CC} and ε_{LL} on STE. To test intra-observer variability, a single observer (ALCA) analyzed the data twice with a minimal interval of 30 days. To test inter-observer variability, a second observer (EYC) analyzed the data without knowing the first observer's measurements.

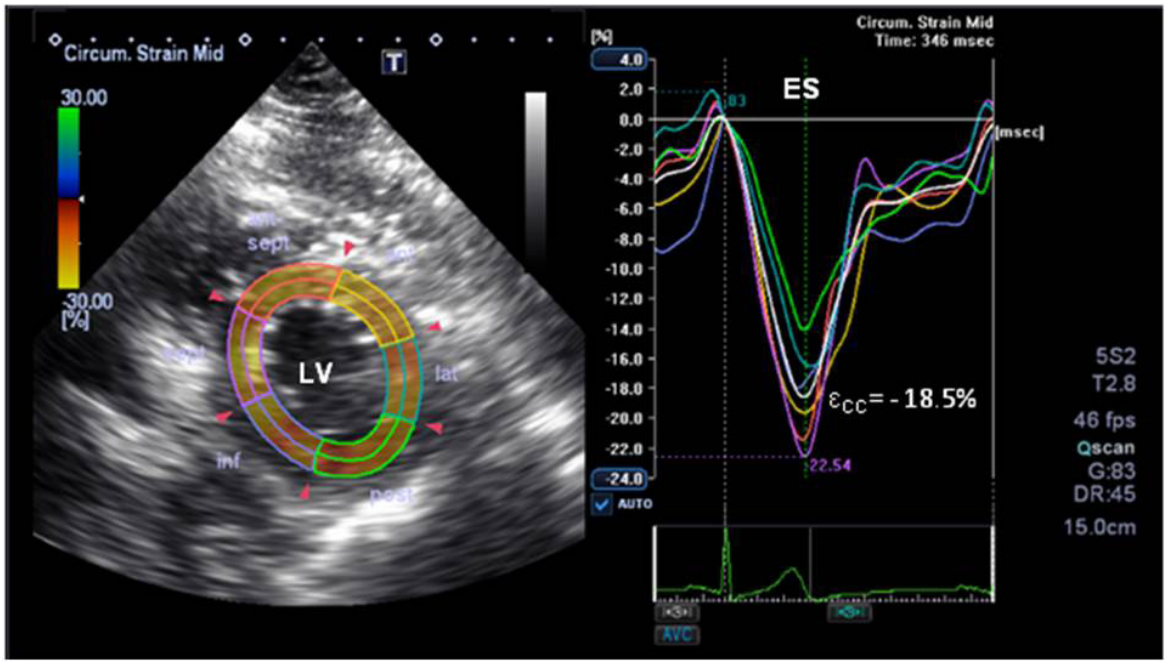

Figure 1 – *Representative LV ε_{CC} curve from a participant without MetSyn. Different colors depict different myocardial segments. The white strain curve represents the global circumferential peak strain. ES: end-systole; ε_{CC}: circumferential strain; LV: left ventricle.*

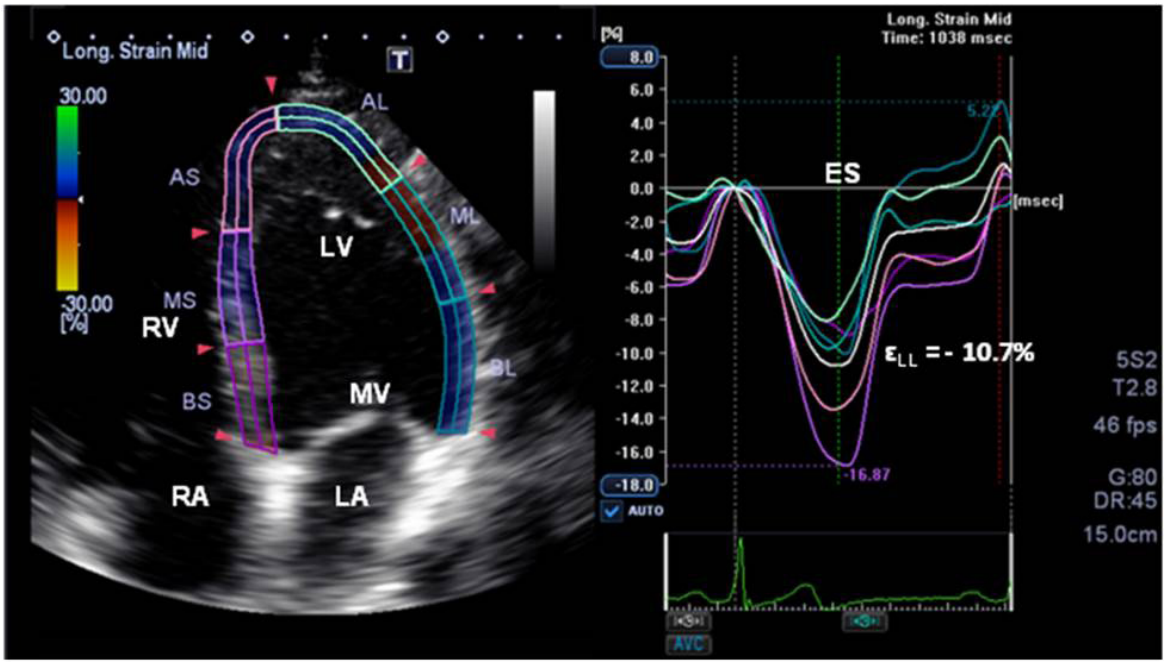

Figure 2 – *Representative LV ε_{LL} curve from a participant with MetSyn. Different colors depict different myocardial segments. The white strain curve represents the global longitudinal peak strain. ES: end-systole; ε_{LL}: longitudinal strain; LV: left ventricle; LA: Left atrium; RV: Right ventricle; RA: Right atrium; MV: Mitral valve*

Statistical analysis

Data are shown as mean ± standard deviation (SD) for continuous variables and as proportions for categorical variables. Student's *t* test was used to assess differences in continuous variables between the groups studied, whereas chi-square test was used for categorical analysis. Univariate analysis was performed to assess the relationship of ε_{CC} and ε_{LL} with the variables of interest. Multiple linear regression (MLR) analysis was performed to study the association between ε_{CC} assessed on echocardiography and variables with a p value < 0.10 in the univariate analysis, and variables with biological plausibility to interfere with LV strain. The same approach was used for ε_{LL} measured on echocardiography and for ε_{CC} measured on tagged MRI. In addition, models of MLR analysis were created, using the stepwise variable selection procedures, to evaluate the potential association of ε_{CC} and ε_{LL} on STE and individual MetSyn components, as well as all the possible term interactions between the MetSyn components. Intra-observer and inter-observer variability was assessed by using intraclass correlation coefficient. A two-tailed p value < 0.05 was considered statistically significant for all analyses. Statistical analyses were performed using the SPSS 18 statistical software package (SPSS Inc., Chicago, IL, USA).

Results

Baseline characteristics

Echocardiography was obtained in 162 consecutive MESA participants. Compared to the entire MESA cohort, this study cohort had higher HDL-cholesterol (57.3 ± 19.0 mg/dL *versus* 52.7 ± 15.6 mg/dL, p < 0.01) and a greater percentage of females (63% *versus* 47%, p < 0.05). Due to enrollment characteristics of the study site, only black and white study participants were included.

Twenty-six (16%) participants were excluded from the analysis because of poor echocardiographic image quality, and three others (1.9%) because of missing data about at least one of the MetSyn components. No participant was excluded because of a history of MI, HF, or LVEF < 50%. The final study population consisted of 133 participants (women: 63%, mean age = 65 ± 9 years).

The prevalence of MetSyn in this sample was 31% (41 MetSyn in 133 participants). Table 1 lists the clinical and demographic characteristics of the participants according to the MetSyn status. The LVEF measured by use of MRI was 61 ± 5%.

Data reproducibility

The inter-observer and intra-observer intraclass correlation coefficients (ICC) for ε_{LL} were 0.84 (p < 0.01) and 0.87 (p < 0.01), respectively. Those for ε_{CC} were 0.86 (p < 0.01) and 0.85 (p < 0.01), respectively.

Metabolic syndrome and LV circumferential strain on STE

Table 2 shows the echocardiographic and MRI data of participants according to the MetSyn status.

The LVEF was similar in both groups (p = 0.09). However, individuals with MetSyn had lower ε_{CC} on STE than those without MetSyn (ε_{CC} = -16.3% ± 3.5% *versus* -18.4% ± 3.7, p < 0.01). Men with MetSyn had lower ε_{CC} on STE as compared with those without MetSyn (-15.5% *versus* -18.6%, p < 0.01). Women with MetSyn tended to have lower ε_{CC} (-16.8% *versus* -18.3%), but with no significance (p = 0.11). The ε_{CC} was similar in women and men with MetSyn (p > 0.05).

Table 1 – Clinical and demographic data of participants according to the MetSyn status

Variable	Without MetSyn (n = 92) Mean ± SD	With MetSyn (n = 41) Mean ± SD	p value
Age (year)	65 ± 8	66 ± 9	0.27
Creatinine (mg/dL)	1.0 ± 0.2	1.0 ± 0.3	0.15
Gender (Female, %)	63%	63%	0.97
Ethnicity (Caucasian, %)	60%	44%	0.09
Smoking (current, %)	8%	10%	0.69
Weight (Kg)	77 ± 17	91 ± 18	< 0.01
BMI (Kg/m^2)	28 ± 5	32 ± 4	< 0.01
Total cholesterol (mg/dL)	197 ± 44	177 ± 39	0.01
LDL-cholesterol (mg/dL)	116 ± 39	101 ± 36	< 0.05
Any lipid-lowering medication (Yes, %)	28%	47%	< 0.05
Waist circumference (cm)*	93 ± 13	107 ± 14	< 0.01
Glucose (mg/dL)*	93 ± 16	107 ± 24	< 0.01
Triglycerides (mg/dL)*	94 ± 46	151 ± 71	< 0.01
HDL-cholesterol (mg/dL)*	62 ± 20	46 ± 11	< 0.01
Hypertension (Yes, %)*	42%	80%	< 0.01

*MetSyn: Metabolic Syndrome; SD: standard deviation; BMI: body mass index; HDL: high-density lipoprotein; LDL: low-density lipoprotein; *: Metabolic Syndrome component.*

Table 2 – Echocardiography and MRI data of participants according to the MetSyn status

Variable	Without MetSyn (n = 92) Mean ± SD	With MetSyn (n = 41) Mean ± SD	p value
ε_{CC} (%) [STE]	-18.4 ± 3.7	-16.3 ± 3.5	< 0.01
ε_{CC} (%) [MRI]	-17.6 ± 2.3	-15.8 ± 3.3	< 0.01
ε_{LL} (%) [STE]	-13.9 ± 2.3	-12.1 ± 2.5	< 0.01
LVEF (%) [MRI]	61 ± 5	59 ± 4	0.09
LV mass (g) [MRI]	120 ± 28	136 ± 35	< 0.01
LV mass index (g/m^2) [MRI]	65 ± 11	68 ± 13	0.18
LVID (mm) [Echo]	46 ± 6	44 ± 5	0.15

ε_{CC}: circumferential strain; ε_{LL}: longitudinal strain; LV: left ventricle; LVEF: LV ejection fraction; LVID: LV internal diameter; MetSyn: Metabolic Syndrome; MRI: magnetic resonance imaging; STE: speckle tracking echocardiography.

In univariate analysis, ε_{CC} on STE was significantly related to the presence of MetSyn ($p < 0.01$), weight ($p < 0.01$), body mass index (BMI) ($p < 0.05$), and WC ($p < 0.01$) (Table 3). The MLR analysis included variables that were significant in the univariate analysis (MetSyn), as well as variables with biological plausibility to change ε_{CC}, such as LVEF, LV mass, age, and ethnicity. Weight, BMI, and WC were excluded from the model because they are directly or indirectly related to the MetSyn definition. In this model, MetSyn was significantly related to ε_{CC} even after adjustment for covariates (B = 2.1%; 95% CI: 0.6-3.5; $p < 0.01$) (Table 3).

In another model of MLR analysis, LVEF, LV mass, age, and ethnicity were maintained, and the MetSyn variable was replaced for all five components of MetSyn. In that case, only WC remained significantly associated with ε_{CC} (B = 2.0%; 95% CI: 0.7-3.3; $p < 0.01$, stepwise method). Again, using all the MetSyn components and all the possible interaction terms between them, only WC maintained significance (B = 2.0%; 95% CI: 0.7-3.3; $p < 0.01$).

The ε_{CC} measured on echocardiography changed from -18.7% in participants with ≤ one MetSyn component to -18.0% in participants with two MetSyn components and to -16.3% in those with ≥ three MetSyn criteria ($p < 0.01$).

The WC component was present in 95.1% of the participants with MetSyn, while blood pressure, HDL-cholesterol, FPG, and triglycerides were present in 87.8%, 61.0%, 46.3%, and 43.9%, respectively. On the other hand, the WC component was present in 45% of the participants without MetSyn.

Metabolic syndrome and LV circumferential strain on tagged MRI

Similarly to STE results, individuals with MetSyn had lower ε_{CC} on tagged MRI than those without MetSyn (ε_{CC} = -15.8% ± 3.3% *versus* -17.6% ± 2.3%, $p < 0.01$) (Table 2).

On univariate analysis, the presence of MetSyn, weight, WC, LVEF, and LV mass were significantly related to ε_{CC} on tagged MRI. On MLR analysis, both the presence of MetSyn (B = 1.3%; 95% CI: 0.3-2.4; p = 0.02) and LV mass (B = 0.02%; 95% CI: 0.01-0.03; p = 0.03) remained significant.

Metabolic syndrome and LV longitudinal strain

Individuals with MetSyn had lower ε_{LL} as compared with those without MetSyn (-12.1% ± 2.5% *versus* -13.9% ± 2.3, $p < 0.01$) (Table 2). This result was consistent for men and women. The ε_{LL} was similar in women and men with MetSyn ($p > 0.05$).

On univariate analysis, ε_{LL} was significantly related to MetSyn, weight, BMI, WC, ethnicity, LV mass, LVEF, creatinine, hypertension status, diabetes status, and triglycerides (Table 4). The MLR analysis included presence of MetSyn, LV mass, LVEF, ethnicity, and creatinine, which were significant in the univariate analysis. Weight, BMI, WC, triglycerides, hypertension, and diabetes status were excluded from the model because they are directly or indirectly related to the MetSyn definition. Presence of MetSyn (B = 1.3%; 95% CI: 0.3-2.2; $p < 0.01$) and LV mass (B = 0.02%; 95% CI: 0.01-0.03; p = 0.02) were independently related to ε_{LL} in the model (Table 4). The results were similar when using LV mass indexed by height in meters: presence of MetSyn (B = 1.3%; 95% CI: 0.3-2.2; $p < 0.01$) and LV mass/height (B = 0.03%; 95% CI: 0.01-0.06; p = 0.04).

In another model of MLR analysis, we maintained LVEF, LV mass, ethnicity, and creatinine, and replaced the MetSyn variable for all five components of MetSyn. With this approach, LV mass (B = 0.02%, $p < 0.01$), ethnicity (B = 1.0%, p = 0.02), and FPG component (B = 1.2%, p = 0.03) remained as independent predictors of ε_{LL} (stepwise method). In a model using LV mass, ethnicity, the five MetSyn components, and all the possible interactions between terms (stepwise method), LV mass (B = 0.02%; 95% CI: 0.01-0.03; $p < 0.01$), ethnicity (B = 0.9%; 95% CI: 0.1-1.8; p = 0.03), and the interaction term WC*FPG (B = 1.5%; 95% CI: 0.3-2.7; p = 0.01) remained significant. The ε_{LL} changed from -14.2% in participants with ≤ one MetSyn component, to -13.4%, in participants with two, and to -12.1% in those with ≥ three MetSyn criteria ($p < 0.01$).

Discussion

In our data, MetSyn, as defined by NCEP ATP III, was associated with reduced myocardial function as indicated

Table 3 – Univariate and multivariate analysis – Dependent variable: ε_{cc} on STE

Independent variables	Univariate analysis			Multivariate analysis		
	B coeff (%)	95%CI	p value	B coeff (%)	95%CI	p value
Presence of MetSyn	2.07	(0.72;3.42)	< 0.01	2.06	(0.59;3.52)	< 0.01
Weight (Kg)	0.05	(0.01;0.08)	< 0.01	-	-	-
Waist circumference (cm)	0.07	(0.03;0.11)	< 0.01	-	-	-
BMI (Kg/m^2)	0.15	(0.03;0.26)	< 0.05	-	-	-
Age (years)	0.02	(-0.06;0.09)	0.60	0.01	(-0.07;0.08)	> 0.05
Ethnicity (Caucasian)	-0.57	(-1.86;0.72)	0.60	-0.87	(-2.17;0.43)	> 0.05
LV mass (g)	0.02	(-0.01;0.04)	0.17	0.01	(-0.01;0.03)	> 0.05
LVEF (%)	-0.03	(-0.13;0.07)	0.51	-0.01	(-0.11;0.10)	> 0.05
Gender (female)	0.17	(-1.16;1.51)	0.80	-	-	-
Creatinine (mg/dL)	-0.18	(-2.97;2.62)	0.90	-	-	-
Smoking status (current)	-0.38	(-2.73;1.97)	0.75	-	-	-
Hypertension (Yes)	0.16	(-1.14;1.47)	0.81	-	-	-
Diabetes (Yes)	0.80	(-1.00;2.60)	0.38	-	-	-
FPG (mg/dL)	0.03	(-0.01;0.06)	0.09	-	-	-
Total cholesterol (mg/dL)	0.01	(-0.01;0.02)	0.95	-	-	-
LDL-cholesterol (mg/dL)	-0.01	(-0.02;0.01)	0.72	-	-	-
HDL-cholesterol (mg/dL)	-0.01	(-0.04;0.03)	0.87	-	-	-
Triglycerides (mg/dL)	0.01	(-0.01;0.02)	0.10	-	-	-

BMI: body mass index; ε_{cc}: circumferential strain; FPG: fasting plasma glucose; HDL: high-density lipoprotein; LDL: low-density lipoprotein; LV: left ventricle; LVEF: LV ejection fraction; MetSyn: Metabolic Syndrome; MRI: magnetic resonance imaging.

by an impaired ε_{cc} and ε_{ll} in a sample of MESA participants. This result becomes even more important considering that this study sample was constituted by asymptomatic individuals with no history of MI, HF, and/or LVEF < 50%. These findings could indicate presence of subclinical CVD in that population. The strength of those relationships was maintained even after adjusting for age, ethnicity, creatinine, LVEF, and LV mass.

Subclinical CVD has been demonstrated in subjects with MetSyn[3-8]. Gong et al. have used tissue Doppler to analyze ε_{LL} in Chinese participants with MetSyn[13]. Consistent with our findings in African-American and Caucasian participants, they have demonstrated that mean systolic ε_{LL} was lower in participants with MetSyn than in controls. In our study, using STE analysis, longitudinal as well as circumferential myocardial functions were reduced, as indicated by lower ε_{LL} and ε_{CC} in participants with MetSyn as compared with those without MetSyn. As MetSyn is more prevalent in African-Americans and Caucasians than in the Chinese population, a more general conclusion can be drawn from our study. Furthermore, strain measured by using Doppler has some limitations such as poor reproducibility, angle dependency, and signal noise[31].

Waist circumference has been cited as a marker of central obesity, carrying a stronger association with health risk indicators[32]. Our data support this concept, because when all five components of MetSyn and all possible interactions between terms were analyzed on MLR analysis, only WC remained significantly associated with ε_{cc} on STE.

The strain difference between participants with and without MetSyn was small. Differences in circumferential and longitudinal myocardial shortening are typically small, particularly in samples of asymptomatic individuals[20,33-35]. Our ε_{cc} values were higher than ε_{ll} in concordance with other results[36]. Participants with MetSyn had lower total and LDL-cholesterol than those without MetSyn, probably due to higher usage of lipid-lowering medication.

Our findings indicate that ε_{cc} was somewhat underestimated on MRI, when compared with ε_{cc} on STE, independently of the presence of MetSyn. The lower temporal resolution of tagged MRI could explain this difference[14,15].

The use of STE could help to improve patient care while providing early identification of subclinical disease[37]. In agreement with other reports[3-6,8,11-13], our results support the association between MetSyn and subclinical CVD. Thus, individuals with MetSyn should be encouraged to improve their quality of life and control all CV risk factors, particularly abdominal obesity.

Limitations

Because of the cross-sectional design of our study, a causal relationship between MetSyn and strain cannot be established accurately. More studies are necessary to evaluate the clinical

Table 4 – Univariate and multivariate analysis – Dependent variable: ε_{LL} on STE

Independent variables	Univariate Analysis			Multivariate analysis		
	B coeff (%)	95%CI	p value	B coeff (%)	95%CI	P value
Presence of MetSyn	1.73	(0.83;2.64)	< 0.01	1.25	(0.32;2.19)	< 0.01
Weight (Kg)	0.04	(0.02;0.07)	< 0.01	-	-	-
Waist circumference (cm)	0.04	(0.01;0.07)	< 0.01	-	-	-
BMI (Kg/m^2)	0.11	(0.03;0.18)	< 0.01	-	-	-
Age (years)	0.02	(-0.03;0.08)	0.37	-	-	-
Ethnicity (Caucasian)	1.11	(0.24;1.97)	0.01	0.85	(-0.0;1.71)	> 0.05
LV mass (g)	0.02	(0.01;0.04)	< 0.01	0.02	(0.01;0.03)	0.02
LVEF (%)	-0.04	(-0.11;0.03)	0.21	-0.02	(-0.08;0.05)	> 0.05
Gender (female)	0.59	(-0.31;1.50)	0.20	-	-	-
Creatinine (mg/dL)	2.10	(0.23;3.97)	0.03	0.29	(-1.74;2.32)	> 0.05
Smoking status (current)	1.23	(-0.35;2.82)	0.13	-	-	-
Hypertension (Yes)	0.97	(0.10;1.84)	0.03	-	-	-
Diabetes (Yes)	1.55	(0.35;2.75)	0.01	-	-	-
FPG (mg/dL)	0.02	(-0.01;0.04)	0.12	-	-	-
Total cholesterol (mg/dL)	-0.01	(-0.02;0.01)	0.33	-	-	-
LDL-cholesterol (mg/dL)	-0.01	(-0.02;0.01)	0.19	-	-	-
HDL-cholesterol (mg/dL)	-0.01	(-0.04;0.01)	0.26	-	-	-
Triglycerides (mg/dL)	0.01	(0.01;0.02)	0.02	-	-	-

BMI: body mass index; ε_{CC}: circumferential strain; FPG: fasting plasma glucose; HDL: high-density lipoprotein; LDL: low-density lipoprotein; LV: left ventricle; LVEF: LV ejection fraction; MetSyn: Metabolic Syndrome; MRI:magnetic resonance imaging.

relevance of our data. Although strain parameters are not disease-specific, strain has been introduced as a sensitive marker of LV systolic function[18-21]. The participants were asymptomatic for HF, and did not undergo exercise stress test to exclude disease at the time of the echocardiographic evaluation. Because reproducibility is better for two-dimensional strain, the strain rate was not analyzed in this study.

Conclusion

These results indicate that LV ε_{LL} and ε_{CC}, markers of subclinical CVD, are impaired in asymptomatic individuals with MetSyn and no history of MI, HF and/or LVEF < 50%. Our findings support strict control of each risk component of MetSynd, mainly WC.

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Author contributions

Conception and design of the research: Almeida ALC, Teixido-Tura G, Lima JAC; Acquisition of data: Almeida ALC, Teixido-Tura G, Choi EY, Opdahl A, Fernandes VRS; Analysis and interpretation of the data: Almeida ALC, Teixido-Tura G, Choi EY, Opdahl A, Wu CO, Lima JAC; Statistical analysis: Almeida ALC, Teixido-Tura G, Choi EY, Opdahl A, Wu CO; Obtaining financing: Lima JAC; Writing of the manuscript: Almeida ALC, Choi EY; Critical revision of the manuscript for intellectual content: Almeida ALC, Teixido-Tura G, Choi EY, Opdahl A, Fernandes VRS, Wu CO, Bluemke DA, Lima JAC.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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