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Comparison of epicardial, abdominal and regional fat compartments in response to weight loss

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Abstract *Background and aims:* Echocardiographic measurement of epicardial fat (EF) seems to be a reliable and diagnostic marker of visceral adipose tissue (VAT). However, the weight loss-induced changes in EF have not been compared with those in VAT or the truncal depot. In this study, we aimed to compare the weight loss-induced changes in EF, VAT and other regional fat compartments in obese men.
Methods and results: In this study, 27 moderately obese men (age 45.8 ± 1.7 years; body mass index 30.5 ± 0.7 kg/m^2) followed a daily low-calorie diet as part of a clinical 12-week weight loss interventional study. We evaluated the EF thickness by transthoracic echocardiography, assessed the abdominal fat tissues by computed tomography scans, and examined the regional and whole body fat compartments by dual X-ray absorptiometry. An average decrease of 26.8% in the initial calorie intake corresponded to post-program reductions of 17.2%, 11.0%, 16.6%, and 29.8% in EF thickness ($P < 0.001$), body mass, percentage fat mass, and abdominal fat compartments, respectively. The percentage change in VAT in response to weight loss was twice as high as the substantial change in EF tissue ($P < 0.001$).
Conclusion: The results of the study suggest that a low-calorie diet-induced weight loss decreases EF thickness. Moderate diet-induced weight loss alone may represent an effective nonpharmacological strategy for reducing EF, which is a unique, pathogenic fat depot and an emerging marker of VAT.

Introduction

In sedentary adults, obesity and weight gain are strongly associated with the development of hypertension [1], hyperlipidemia [2] and insulin resistance [3], all of which

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are risk factors for cardiovascular disease [4]. The excessive fat ubiquitously accumulates in the abdominal viscera, subcutaneous tissues [5,6], myocytes [7], hepatic cells and intramuscular cells [8], leading to insulin resistance and impaired metabolic control in the general population. Fat accumulation in the epicardial tissue has been recognized as a potential additional marker of cardiac risk and as an indicator for the development of an unfavorable metabolic risk profile [9—11]. Therefore, in obese humans, the fat distribution in the body may be an important predictor of metabolic and cardiovascular abnormalities.

The increasing prevalence of obesity has resulted in an increase in the research on diet-induced weight loss interventions—the most common method of obesity reduction [12]. In a recent study, subjects who underwent a 6-month-long weight loss program (weight loss by an average 20 kg) by adhering to a very low-calorie diet (900 kcal/day) were found to show decreased epicardial fat (EF) thickness, which is associated with changes in the fat distribution in severely obese subjects [13]. Moreover, in severely obese patients, the weight loss after bariatric surgery (weight loss by an average 40 kg) contributed to a decrease in epicardial adipose tissue [14]. However, in the case of severely obese patients, adherence to a very low-calorie diet can be extremely strenuous for the patients, and bariatric surgery requires invasive approaches; moreover, the studies on these approaches provide little information on the effect of the interventions on body fat compartments such as abdominal fat and on the regional fat composition.

It is important to identify the independent role of less invasive methods, such as diet restriction, on the reduction in EF and other anatomical body fat compartments. Therefore, we hypothesized that the diet-induced weight loss in moderately obese men has variable effects on the changes in EF, abdominal fat and fat distributions in other regions. In the present study, we aimed to determine whether a moderate energy-restricted diet alters the ventricular EF thickness, abdominal fat and regional adipose tissue compartments and whether the pattern of the changes in these fat compartments varies among obese men. The subjects in the study were asked to adhere to a low-calorie diet that could be easily incorporated into daily life, and the effects of the diet on various fat tissues were identified.

Methods

Participants

The subjects were recruited through advertisements in local newspapers. The participants were healthy, were not taking any medication known to alter glucose and lipid metabolism, and were reportedly free of any acutely or chronically diagnosed cardiovascular disease (cardiovascular, cerebrovascular, liver, renal, hematological or thyroid), and weight loss less than $\pm$2 kg/6 months before the study commencement. The nature, purpose and potential risks of the study were explained to all the subjects, and voluntary informed written consent was obtained from each subject before participation. This study was conducted in accordance with the guidelines proposed in The Declaration of Helsinki and the study protocol was reviewed and approved by the Ethics Committee, University of Tsukuba, Japan.

Anthropometric measurements

Height and body mass were measured while the participants were fasting and barefoot (TBF-215; Tanita, Tokyo, Japan). Body mass index was calculated as body weight divided by height squared. Waist circumference was measured at the level of the umbilicus in light clothing with the participants in the standing position.

Regional body composition by DXA

Dual energy X-ray absorptiometry (DXA) was performed using a Lunar (software version 1.3Z, DPX-L; Lunar, Madison, WI) to evaluate body composition, which was assumed to consist of fat mass and fat- and bone-free mass, as previously described [15]. A standard soft tissue examination includes total body and regional measurements of trunk, arms and legs to analyze body composition according to a three-compartment model including fat mass and lean and bone mineral content. The pixels of soft tissue were used to calculate the ratio of mass attenuation coefficients at 40—50 keV (low energy) and 80—100 keV (high energy). The subjects lay in the supine position with their arms and legs at their sides during the 15-min scan; radiation exposure was $<$7 μSv. The same operator performed all the scans and daily quality assurance tests were performed according to the manufacturer's directions.

Abdominal fat by CT

In the second measurement session, abdominal visceral fat and the subcutaneous fat area were measured using computed tomography (CT) scans (SOMATOM AR.C; Siemens, Germany) set at 110 kVp and 50 mA. A single 5-mm scan with a scanning time of 5 s was obtained, centered at the level of the umbilicus (fourth and fifth lumbar vertebrae) in the supine position with the participants' arms extended above the head during the measurements. The images were digitized by optical density to separate the bone, muscle and fat compartments. The visceral fat and subcutaneous fat area were calculated using a computer software program (Fat Scan; N2 system, Osaka, Japan), as previously described [16,17].

Epicardial adipose tissue by echocardiography

For direct assessment of EF tissue, each participant underwent echocardiography as proposed by Iacobellis et al. [18—20]. With the subjects in the left lateral decubitus position, two-dimensionally guided M-mode echocardiography was performed using an Envisor C, Philips with a 2.5-MHz transducer. The largest dimension of this space was in the end-diastolic period and was measured from the trailing edge to the leading edge on the free wall of the right ventricle; this measurement was considered as the maximum EF thickness in 2 standard echocardiographic views, namely the parasternal long-axis and short-axis