MAYO CLINIC

3-D Body Scanners – Body Volume Index: A Novel, Reproducible and Automated Anthropometric Tool Associated with Cardiometabolic Biomarkers

Abel Romero-Corral, MD, MSc[1]; Virend K Somers, MD, PhD[1]; Francisco Lopez-Jimenez, MD, MSc[1]; Yoel Korenfeld, MD[1];
Suzanne Palin MRCP (UK), MD[2]; Kristien Boelaert MRCP, PhD[3]; Simona Boarin, MD[4]; Justo Sierra-Johnson, MD, MSc[5]; and Asad Rahim, MRCP (UK), MD[2]
[1]Division of Cardiovascular Diseases, Department of Medicine – Mayo Clinic, Rochester; [2]Department of Diabetes and Endocrinology, Birmingham Heartlands Hospital, Bordesley Green East, Birmingham;
[3]Institute of Biomedical Research, Division of Medical Sciences, University of Birmingham, [4]Istituto Auxologico Italiano San Luca, Italy.
[5]Department of Medicine, Atherosclerosis Research Unit, Karolinska Institute, Sweden

Background

The assessment and treatment of obesity remains poor despite an increase in prevalence. Furthermore, strong evidence suggests that overweight and mild obesity, defined using the body mass index (BMI), are related to better survival and fewer cardiovascular (CV) events in several patient populations worldwide.

These findings go against medical knowledge relating excess in body fat to several harmful conditions, including diabetes, heart disease and several types of cancer. Nevertheless, mild elevations in BMI have failed to confirm this perception (The obesity paradox).

A feasible explanation for the lack of association between BMI elevations and increased mortality and CV events could be the poor diagnostic performance of BMI to detect obesity. With that in mind, there is an urgent need for an obesity measure that can be easily performed, with no risk involved for the patient, and that can accurately estimate not only the impact of obesity as a health hazard on the population but also at individual basis.

For several years, 3D scanners have been widely used in the retail-clothing sector to measure body shape. Recently, this technology has been developed in a unique way to estimate the body volume in humans. The new software allows the 3D image of the body to be used not only to extract the amount of total body volume, but the volume in all segments of body. The body volume (BV) is quickly (7 seconds) and easily obtained, and does not involve risk for the patient, such as radiation or water submersion.

Objective

To examine the reproducibility of 3-D body volume (BV) scanners in estimating BV, and explore its potential use as an anthropometric measure to assess obesity-related CV risk.

Methods

We recruited 53 consecutive (77% female) healthy adult volunteers from the general population (Birmingham, UK).

Anthropometric measures included height, weight, waist and hip circumferences. Body fat was estimated by bioimpedance. Total/regional BV, waist/hip circumferences were estimated using a 3-D BV scanner, an automated procedure that utilizes cameras (no radiation) and sensors to create a 3-D body image of the individual in 7 sec. (figure 1 and 2)

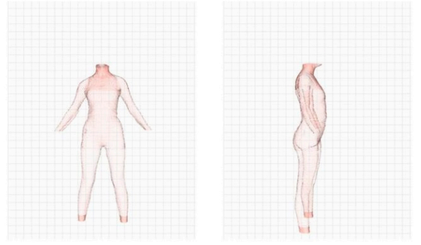
Blood samples were collected to measure biomarkers of CV risk. Data were analyzed to explore correlations between BV and CV biomarkers. Possible BV indices were calculated to assess CV risk. Reproducibility of BV was determined by measuring 15 subjects twice, 15-min apart.

Figure 1

3D Body Volume Scanner -BVI Scanner

Figure 2

Body Volume Report



Body Section	% Agnst Total Body Volume	Weight Distribution	Variance Against National Average	Body Section	% Agnst Total Body Volume	Weight Distribution	Variance Against National Average
Neck	1			R.Leg	13		
Chest	43			L.Leg	13		
Abdomen	15			Waist	Girth: 87.0		
Pelvis	9			Mid Abdomen	Girth: 104.2		
R.Arm	3			Hip	Girth: 98.9		
L.Arm	3			Head,hands&feet			

Results

Mean age (±SD) was 51 ± 14 years, BMI was 30 ± 2 kg/m2, waist circumference was 98 ± 10 cm, body fat was 38 ± 6 % and total BV was 77 ± 8 Lt. Intra-individual variability mean (±SE) of BV was -0.58 ± 0.7 Lt (p=0.43). Table 1 displays the Spearman correlations between anthropometric variables and BV estimated with biomarkers of CV risk.

Table 2 shows possible BV indices to assess CV risk. Overall, BV indices appeared to correlate better with biomarkers of CV disease than conventional obesity measures.

Table 1. Correlations between Obesity Measures and Biomarkers of CV risk

Variable	*Non HDL-cholesterol*	*Glucose*	*CRP*
Body mass index, kg/m2	0.13	0.27^	0.36*
Waist circumference, cm	0.11	0.46+	0.17
Hip circumference, cm	0.12	0.07	0.37*
Waist-to-hip ratio	0.10	0.49+	0.001
Body fat, %	0.33^	0.13	0.22
Total and Regional Volumes			
Total Volume, Liters	-0.02	0.12	0.33*
Arms Volume, %	-0.32^	-0.0001	0.06
Chest Volume, %	-0.02	0.31*	-0.003
Abdominal Volume, %	0.39*	0.18	0.11
Pelvis Volume, %	0.02	-0.25	0.04
Legs Volume, %	-0.19	-0.44**	-0.25

^ p <0.07; * p <0.05; ** p <0.01; + p <0.001; ++ p <0.0001

Table 2. Correlation between Biomarkers of CV risk and Body Volume Index Candidates

Variable	*Non HDL-cholesterol*	*Glucose*	*CRP*
Possible Body Volume Index - BVI			
Chest*Abdomen*Arms Legs / Total Volume	0.37^	0.58+	0.38*
Chest*Abdomen / Legs Ht2	0.38*	0.53+	0.43*
Abd (Chest + Arms) / Legs Ht2	0.42*	0.54+	0.36^
Chest (Abd + Arms) / Legs Ht2	0.39*	0.60++	0.35^

^ p <0.07; * p <0.05; ** p <0.01; + p <0.001; ++ p <0.0001

Conclusions

3-D BV scanners are able to accurately reproduce BV estimates. Total/regional BV estimates were positively and significantly correlated with biomarkers of CV risk. Finally, BV indices calculations correlated significantly with all biomarkers of CV risk, suggesting that BV indices may be a better tool to assess CV risk than conventional obesity measures.