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Anthropometrics by three-dimensional photonic scanner in patients with obesity before and after bariatric surgery

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Abstract

Background—We studied body composition by three-dimensional photonic scanning (3DPS) and metabolic biomarkers in a large ethnically diverse cohort of individuals with severe obesity before and after weight loss by Roux-en-Y gastric bypass (RYGB) or adjustable gastric banding (AGB) surgery.

Materials and Methods—Male and female participants (n=95) underwent 3DPS testing in the weeks preceding bariatric surgery (baseline), and one year after either RYGB (n=34) or AGB (n=9).

Results—Principal component analysis showed that A1C and HDL cholesterol clustered with waist-to-hip ratio (WHR). Both RYGB and AGB surgeries led to similar improvements in A1C and lipids after one year. RYGB led to greater decreases in body weight and in most anthropometric measures compared to AGB at one year. However, after accounting for weight loss differences, RYGB and AGB groups did not differ in regional decreases in circumferences or volumes; the exception was a greater reduction in lean mass in RYGB compared to AGB.

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Authors' contribution. AS helped with data analysis and manuscript writing. WWY, DG, and MAT performed the 3DPS measurements and edited the manuscript. MP, SD, PR, analyzed some of the data. B. Laferrère designed the study, collected and analyzed the data, and wrote the manuscript. All co-authors reviewed the final manuscript. B. Laferrère is the guarantor of this work and as such had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Part of the data was presented as a poster at 2017 ObesityWeek Conference.

Conflicts of Interest. The authors declare that they have no conflict of interest.

Informed Consent. Informed consent was obtained for all individual participants included in this study.

Ethical Approval. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conclusion—Distribution of weight loss, assessed by 3DPS, did not differ between RYGB and AGB, but surgery type predicted change in lean mass at one year.

Keywords

body composition; gastric bypass; gastric band; three-dimensional photonic scanning (3DPS); dyslipidemia; type 2 diabetes mellitus

Introduction

The prevalence of obesity has risen to alarming levels in the past several decades and currently more than 1 in 3 adult Americans have obesity [1]. Obesity, and specifically an upper body distribution of fat [2], is associated with several metabolic risk factors including dyslipidemia and insulin resistance [3]. Lifestyle interventions result in short-term weight loss in individuals with obesity, but these effects are often not sustained [4]. Thus, bariatric surgery, including Roux-en-Y gastric bypass (RYGB) or adjustable gastric banding (AGB), has become a critical treatment option for individuals with severe obesity. Bariatric surgery results in significant and prolonged weight loss and beneficial changes in body composition [5, 6]. RYGB is associated with more favorable weight loss and metabolic outcomes, including type 2 diabetes mellitus (T2D) improvement, than AGB [7, 8].

Body composition studies are notoriously difficult in individuals with obesity [9, 10]. Traditional tape measurements are poorly reproducible and may be inaccurate [11]. Imaging techniques, such as magnetic resonance imaging (MRI) and computed tomography (CT) are often unavailable for individuals with obesity due to weight or body size limits. The three-dimensional photonic scanner (3DPS) generates a three-dimensional body image (Figure 1) and provides accurate total and regional body volumes (in liters) and circumferences (in millimeters) and lengths (in millimeters) with a 10-second scan [12]. This non-invasive method, which does not have weight cutoffs, has been validated against other body composition methods and can precisely measure anthropometrics in individuals with obesity, in addition to providing an assessment of fat mass [12–14]. Few studies have used 3DPS to assess body composition [14–16] and none have used it to assess changes in body composition after surgical weight loss. African-Americans and Hispanics are disproportionately affected by obesity compared to Caucasian Americans [1]. Prior reports have shown differences in body composition between the three ethnic groups even when accounting for body mass index (BMI) and height [17]. Further, minority populations are often under-represented in bariatric cohorts [18, 19] and less likely to get bariatric surgery compared to their Caucasian counterparts [20].

The goals of this study were 1) to characterize anthropometric phenotype and ethnic differences in a large cohort of individuals with severe obesity using the 3DPS method; and 2) to assess changes in body composition and distribution of weight loss by 3DPS one year after two different bariatric surgery procedures, RYGB and AGB. We hypothesized that the greater metabolic improvement after RYGB compared to AGB would be associated with greater decreases of anthropometric markers of upper body fat distribution.

Methods

Study Design

This was a prospective observational non-randomized cohort study of individuals with obesity undergoing either RYGB or AGB. Data were derived from two large cohorts of patients (NCT01516320 and NCT02287285) studied to investigate the role of gut hormones in metabolic improvement after bariatric surgery [8, 21, 22]. Given the inclusion criteria of these cohort studies, nearly all the participants had documented evidence of T2DM prior to bariatric surgery. Participants had one fasting blood draw and 3DPS testing prior to and one year after surgery. The body compositon data have not been published elsewhere.

Subjects

Individuals with severe obesity, scheduled to have either laparoscopic RYGB or AGB at St Luke's Roosevelt Hospital between 2007 and 2016, provided written informed consent prior to participating. Exclusion criteria included active malignancy, recent (<6 months) cardiovascular disease, kidney or liver dysfunction, pregnancy and hypertriglyceridemia (>600 mg/dL). Ethnicity was self-identified by subjects into the categories Caucasian, Hispanic, African-American, and Asian. All research protocols were approved at St. Luke's Roosevelt Hospital and at Columbia University.

Surgery

The same bariatric team performed all surgical procedures as described previously [8]. For RYGB, the jejunum was divided 30 cm from the ligament of Treitz and anastomosed to a 30 mL promimal pouch and the jejunum was re-anastomosed 150 cm distal to the gastrojejunostomy. For AGB, a silicone adjustable band (~10–12 mm diameter) was placed around the proximal portion of the stomach, creating a 30 mL pouch. Adjustment of the band with saline was performed as needed. Subjects were free-living and followed the recommended post-operative bariatric diet of clear liquids during week 1, pureed diet during weeks 1–3, and solid foods starting at week 4. The diet was not otherwise controlled or monitored.

Body weight and height

Body mass was measured to the nearest 0.1 kg (Ohaus Champ General Purpose Bench Scale, Ohaus Corp., Pine Brook, NJ) and height to the nearest 1 mm using a stadiometer (Holtain Ltd., Crymych, U.K.) while the subjects wore minimal clothing with no shoes and after voiding.

Body Composition

The 3-D photonic scans (Model# C9036–02 Body Line Scanner; Hamamatsu Photonics K.K, Japan) were performed at the New York Nutrition Obesity Research Center Body Composition Unit at St. Luke's Roosevelt Hospital until 2014, and thereafter at Columbia University when the Body Composition Unit including all equipment moved there. The 3DPS scanner system and procedures have been previously described in detail [12–15]. During scan acquisition, participants wore a tight-fitting cap to minimize air spaces between the hair and skull and well-fitting underwear that clung to the skin surface. Arms were positioned with hands holding the handlebars, and participants stood on footprints, which were equidistant from the center point. With this standardized position, participants' arms were abducted from the trunk, and there was no contact between the legs. Participants were asked to remain motionless during scanning that included three repeated scans during normal breathing.

Assays

Determinations of plasma concentrations of glucose by the glucose oxidase method (Analox Instruments, Lunenburg, MA) and of insulin by radioimmunoassay were performed by the Columbia University Diabetes Research Center Translational Biomarker Analysis Core. The lipid panel and A1C levels were completed at respective hospital pathology laboratories.

Calculations

Insulin resistance was estimated as the homeostasis model assessment of insulin resistance (HOMA-IR): (fasting-insulin$_{\mu U/mL}$ × fasting-glucose$_{mg/dL}$)/405 [23].

Statistical Analysis

Normality was tested for all variables and non-parametric tests were used if variables were not normally distributed. In comparing unadjusted continuous variables between the 2 surgical groups, independent t-tests or Wilcoxon-Mann-Whitney tests were used. To compare means of metabolic and 3DPS variables across the three ethnic groups, ANOVA with Tukey post-hoc analysis was used. Chi-square analysis assessed differences for categorical variables. Pearson correlation and Kendall rank test was used to test for correlations among normally and non-normally distributed data, respectively. Multiple linear regression analysis was used to test the effect of surgery type and percent weight loss on changes in lipid parameters, HOMA-IR and 3DPS variables one year after intervention; B values, or unstandardized beta coefficient from the regression model, are reported.

Because of the large number of 3DPS variables, principal component analysis (PCA) was performed to extract those components that explained a significantly large proportion of the total variation in the data set. Principal components (PC) with an eigenvalue > 1 are reported. Important variables that composed a PC were determined by the variable-component correlation within the component correlation matrix (signifcance: variable-component correlation >0.400 or <−0.400). All analysis was done using SPSS 26 (Armonk, NY) with p-value < 0.05 (two-tailed) considered significant. Data are expressed as mean ± standard deviation.

Results

Baseline

Ninety five participants with severe obesity were studied by 3DPS with BMI ranges from 35.71 to 58.17 kg/m^2 and ages from 21 to 64 years (Table 1). Subjects were predominantly women (77%), Hispanic or African Americans (>91%), and diagnosed with T2D (92%). Women and men had similar BMI, yet compared to men, women weighed less, were shorter, and had higher percent body fat which also meant less lean mass. Women had significantly lower waist circumference, waist-to-hip ratio (WHR), neck circumference (CIR), chest CIR and lower torso volume (VOL). Women had higher HDL cholesterol than men (48.3 ± 14.5 versus 40.8 ± 9.8 mg/dL, p=0.015), but A1C, HOMA-IR, total and LDL cholesterol, and triglycerides did not differ by gender (Table 1). Participants completed 3DPS measurements without incident or complaint.

As men and women have vastly different anthropometric measures, and given few men in the sample, ethnic differences were studied in women only. Among women, compared to Hispanics, African Americans had significantly higher weight, BMI, chest CIR, hip CIR, total body volume, and lean mass; these differences disappeared after controlling for weight and height or for BMI (Table 2). There were no differences between Caucasian women and either Hispanic or African-American women, but the female Caucasian cohort was small.

HOMA-IR was correlated with neck CIR (r=0.166, p=0.032) (Figure 2A). HDL cholesterol was inversely correlated to WHR (r=−0.300, p=0.005), neck CIR (r=−0.241, p=0.027) and lean mass (r=−0.281, p=0.012). The only anthropometric measure that correlated with triglycerides was chest CIR (r=0.155, p=0.036).

PCA of 3DPS and metabolic variables yielded 5 significants PCs with an eigenvalue > 1 (Table 3). PC1 and PC2 showed clustering of different 3DPS variables while PC3 and PC5 were composed of different metabolic parameters. PC4 was the only PC to be an aggregate of both metabolic and 3DPS variables and showed clustering of HDL cholesterol, A1C and WHR.

Changes After Bariatric Surgery

Metabolic biomarkers (lipids, A1C, and HOMA-IR) and 3DPS variables did not differ between RYGB and AGB participants prior to intervention (Table 4). Compared to AGB, RYGB, as expected, resulted in a greater percent total weight loss (29% versus 18%, p=0.003), greater decreases in lean mass, waist CIR, hip CIR, torso VOL and total body VOL (Table 4). Changes in lipids and A1C did not differ across surgical groups one year after intervention. Percent changes in HOMA-IR significantly correlated with percent body weight changes (r=0.355, p=0.02), percent changes in total body VOL (r=0.361, p=0.017) and percent changes in fat mass (r=0.331, p=0.03) (Figures 2B, C and D).

Regression analysis showed that surgery type predicted percent HOMA-IR changes at one year (B=−13.26, p=0.044) such that RYGB accounted from an additional 13.26% reduction in HOMA-IR compared to AGB. However, surgery type did not predict changes in fat mass, percent body fat, WHR or neck CIR at one year. After adjusting for weight loss, in a multiple linear regression analysis, surgery type had no effect on changes in any anthropometric measure but one. Surgery type (B=5.736, p=0.046) and amount of weight loss (B=−0.202, p=0.034) strongly predicted changes in lean mass with greater decrease in lean mass after RYGB compared to AGB.

Discussion

Our study aimed to assess anthropometric measurements by 3DPS in a large group of ethnically diverse adults before bariatric surgery and to study the changes in body composition after two types of bariatric surgeries. The results using 3DPS confirm established gender and ethnic differences in body composition. Women had less lean body mass and less upper body volumes and circumferences, surrogates of less upper body fat distribution, than men, as previously reported [24].

African-Americans were significantly heavier than Hispanic participants, as described in another large ethnically diverse, predominantly female bariatric cohort [25], but did not differ in fat mass or percentage body fat. This is in contrast to previous reports which showed ethnic differences in adiposity, measured by dual-energy X-ray absorptiometry (DXA). In these studies of leaner adults of both genders from three ethnic groups of comparable BMIs, African-Americans had lower percent body fat compared to Caucasians who had lower fat mass compared to Mexican-Americans [17, 26, 27].

Our study showed significant differences between African-American and Hispanic women with the former having higher body weights with greater chest CIR, hip CIR, total body VOL and lean mass. Jones et al found that African-American women with non-obese BMIs (BMI 25.5 ± 4.9 kg/m^2) had higher lean mass as measured by DXA compared to Caucasian women with BMIs of 25.5 ± 4.9 kg/m^2, with no differences in fat mass and bone mass [28]. Similar to our findings, a prior study comparing body anthropometrics by 3DPS showed no regional differences between Hispanic (BMI 32.47 ± 8.06 kg/m^2) and Caucasian (BMI 34.57 ± 9.1 kg/m^2) women with obesity [15]. Collectively, these findings suggest that ethnic differences in body composition may exist in women and that these differences may vary by BMI category. The limited number of men in our cohort did not allow for investigation of ethnic differences in anthropometric measures.

Neck girth was the only anthropometric measure to correlate with insulin resistance in our cohort; however the correlation was not strong likely due to a fairly homogenous sample. Neck girth has been shown to be a strong marker of metabolic risk in a subanalysis of the Framingham Heart Study where it correlated with blood pressure, LDL cholesterol, triglycerides, glucose levels and HOMA-IR, even after adjusting for BMI and waist circumference [29]. PCA showed that most 3DPS variables clustered amongst themselves and metabolic variables did the same. However, one PC showed clustering between A1C, HDL cholesterol and WHR. This is in agreement with work by others who have shown a higher WHR was correlated with insulin resistance [30, 31] and lower HDL levels [32].

Despite greater weight reductions by RYGB, there were no differences in the rates of T2D remission, insulin use and HOMA-IR one year after surgical intervention between the two surgical cohorts, unlike other studies which showed greater improvement in glucose control after RYGB compared to AGB [7, 33, 34]. This was likely due in part to our small AGB cohort size, high attrition rate, the significant weight loss observed after AGB, the possible bias in the selection of participants with short known diabetes duration, well controlled diabetes and not treated with insulin [8], and the short-term follow up. All these limitations likely reduced our power to detect differences in T2D remission between the two procedures. In addition, the study cohort had well controlled diabetes with a collective pre-surgery A1C of 6.97 ± 1.10%; the diabetes may not have been severe enough to show the increased efficacy of RYGB for glycemic control. While changes in HOMA-IR correlated with changes in weight, total body volume and fat mass, surgery type was not significant in predicting HOMA-IR one year after intervention, even after adjusting for weight loss differences between the two surgery groups.

While RYGB led to greater weight loss and greater decreases in most anthropometric measures, the distribution of weight loss, i.e. the distribution of the change in regional body circumferences and volumes measured by 3DPS, was similar in the two surgery groups. Weight loss by RYGB does not affect preferentially the decrease of upper body volumes and circumferences. These results, which are contrary to our working hypothesis, may need to be verified with a larger comparative surgical group, as the number of participants followed after AGB was small. There was a significantly greater reduction in lean mass after RYGB compared to AGB. This has been shown in other bariatric cohorts. Compared to AGB, RYGB resulted in greater loss of fat free mass, measured by whole body MRI, one year after intervention in one study [35] and two years after intervention in another study using bioelectric impedance analysis [36]. Similarly, in other studies using DXA, there were significant reductions in lean tissue mass one year after RYGB [37] as well as after vertical sleeve gastrectomy [38]. Collectively, these results validate the changes we observed in our bariatric cohort using 3DPS technology.

Strengths of this study include a large sample size, ethnically diverse subject population, and concomitant longitudinal measures of 3DPS and metabolic risk factors. However, this study has limitations: significant attrition one year after surgery, follow-up limited to one year after intervention, uneven distribution of gender with female predominance, and few participants who underwent AGB. Our study did not include vertical sleeve gastrectomy which is currently the predominant bariatric procedure [39].

Conclusion

In summary, 3DPS is a non-invasive, well accepted method useful to assess body composition in individuals with obesity and its changes after bariatric surgery. RYGB led to greater weight loss compared to AGB after one year but without difference in the distribution of weight loss. Future studies should focus on changes in body composition using 3DPS with longer follow-up and in vertical sleeve gastrectomy patients.

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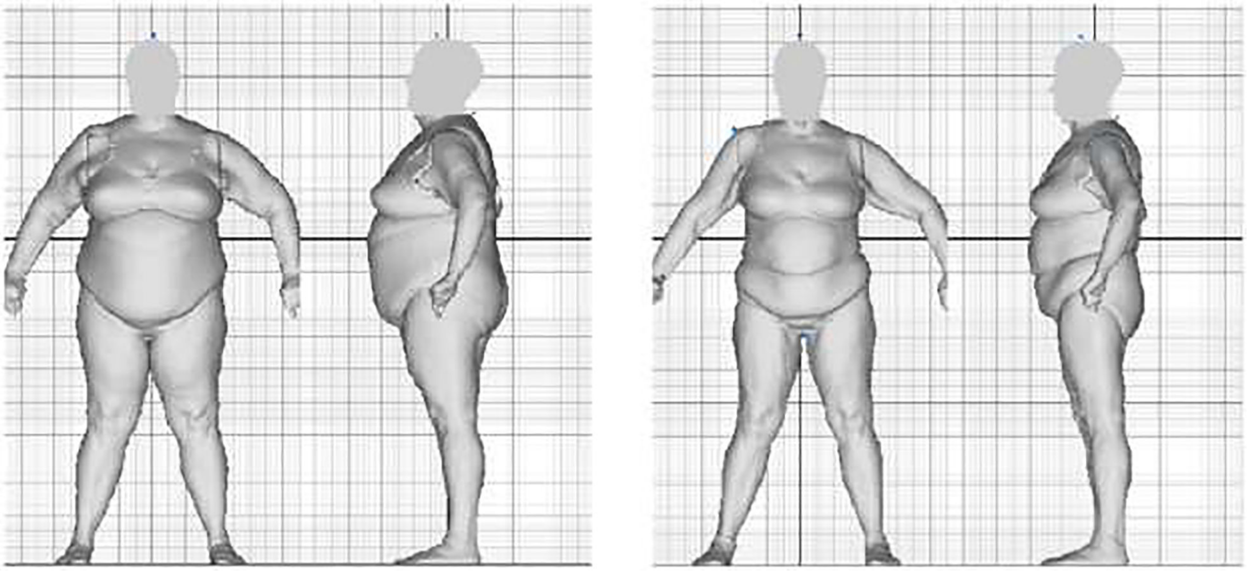

Figure 1.
Representative 3DPS images in a participant before (left) and after (right) Roux-en-Y gastric bypass surgery.

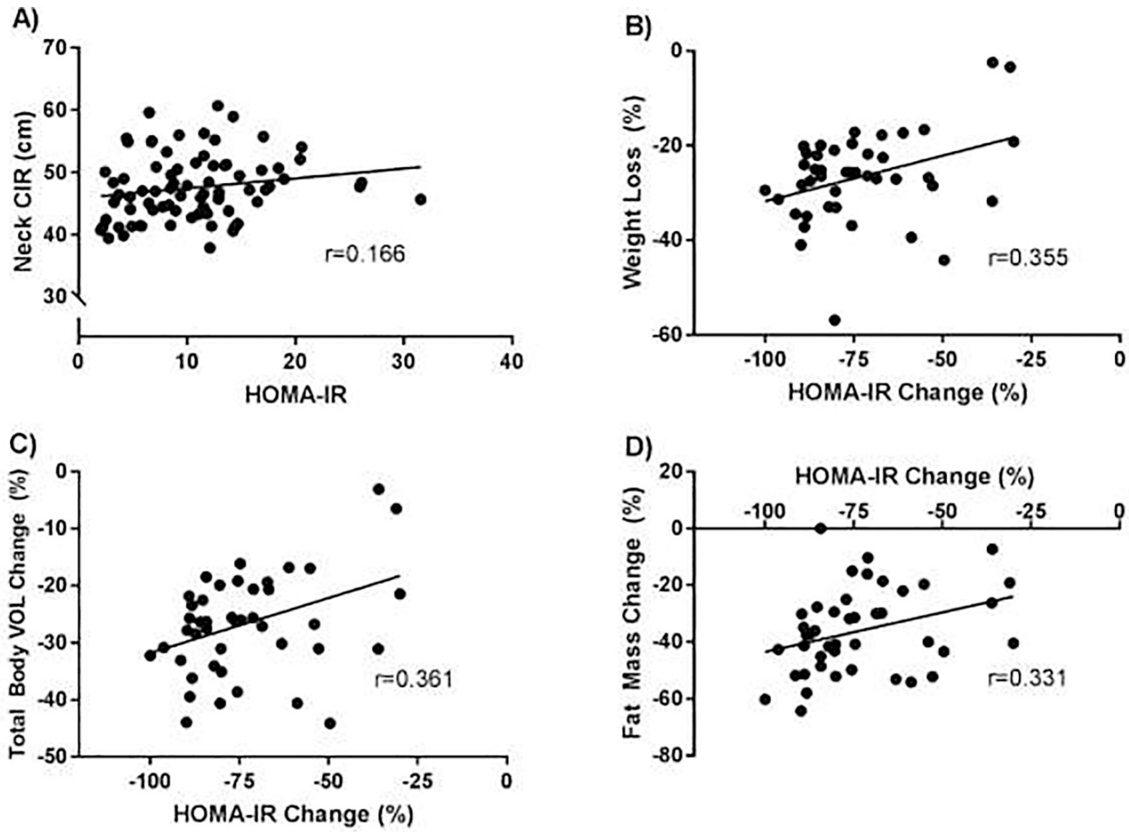

Figure 2.

Correlation between neck CIR and HOMA-IR in cohort with obesity prior to surgical intervention (A). Changes in HOMA-IR correlate with changes in weight loss (B), total body VOL (C), and fat mass (D) in RYGB and AGB subjects 1 year after surgical intervention.

Table 1.

Baseline characteristics of participants.

	Entire Cohort	Range	Women	Men
N	95		73	22
Ethnicity (C/H/AA/A)	7/55/32/1		5/41/27/0	2/14/5/1
Age (years)	43.80 ± 9.5	21–64	43.82 ± 9.2	43.73 ± 10.6
Weight (kg)	116.7 ± 18.8	79.83–184.10	111.2 ± 15.3 ***	134.9 ± 18.2
Height (cm)	164.2 ± 8.5	147.6–188.0	161.1 ± 6.3 ***	174.2 ± 7.1
BMI (kg/m^2)	43.36 ± 4.65	35.71–58.17	43.15 ± 4.79	44.09 ± 4.21
Total cholesterol (mg/dL)	182.2 ± 36.0	106–281	183.7 ± 36.1	177.5 ± 36.1
Triglycerides (mg/dL)	146.1 ± 69.3	55–359	146.52 ± 73.6	144.7 ± 54.8
HDL cholesterol (mg/dL)	46.5 ± 12.24	22–82	48.3 ± 14.5 *	40.8 ± 9.6
LDL cholesterol (mg/dL)	106.7 ± 29.3	54–176	106.3 ± 28.4	107.8 ± 32.6
HOMA-IR	10.61 ± 5.83	2.02–31.57	10.18 ± 5.74	11.95 ± 6.05
A1C (%)	6.97 ± 1.10	4.9–10.0	6.87 ± 1.06	7.31 ± 1.19
Number with T2D (%)	88 (92.6%)		66 (90.4%) ***	22 (100%)
Number using insulin (%)	13 (13.7%)		12 (16.4%)	1 (4.5%)
Neck CIR (cm)	47.32 ± 5.23	37.06–60.72	45.73 ± 4.45 ***	52.51 ± 41.85
Chest CIR (cm)	130.6 ± 92.6	105.9–156.2	129.3 ± 8.91 *	134.8 ± 9.33
Waist CIR (cm)	124.9 ± 12.27	95.70–156.11	122.2 ± 10.59 ***	133.9 ± 13.39
Hip CIR (cm)	132.1 ± 11.41	100.5–158.6	132.9 ± 10.24	129.7 ± 14.7
Waist-to-hip ratio	0.95 ± 0.08	0.71–1.41	0.92 ± 0.06 ***	1.04 ± 0.10
Torso VOL (L)	80.58 ± 14.85	53.74–133.9	76.02 ± 10.72 *	95.71 ± 16.78
Total body VOL (L)	119.8 ± 18.95	82.78–187.1	114.92 ± 15.93 ***	136.18 ± 19.32
Body fat (%)	49.10 ± 7.59	33.31–69.85	50.85 ± 6.69 ***	43.31 ± 7.65
Fat mass (kg)	57.57 ± 12.23	36.66–96.86	57.09 ± 11.05 ***	58.98 ± 15.42
Lean mass (kg)	59.23 ± 13.76	31.45–96.12	53.94 ± 9.93 ***	74.84 ± 11.56

Data are mean ± SD.

* p <0.05

** p<0.01

*** p<0.001 for t-test between gender. Abbreviations. A: Asian; AA: African-American; C: Caucasian; CIR: circumference; H: Hispanic; HDL: high-density lipoprotein; LDL: low-density lipoprotein; VOL: volume.

Table 2.

Baseline demographics and 3DPS measurements in women by ethnic groups.

	Caucasian	Hispanic	African-American	ANOVA
N	5	41	27	
Age (years)	51.60 ± 6.35	42.77 ± 10.60 *	43.93 ± 6.69	0.131
Weight (kg)	106.4 ± 19.80	107.2 ± 12.06 **	118.2 ± 16.91	0.010
Height (cm)	160.5 ± 6.11	160.3 ± 6.23	162.5 ± 6.50	0.393
BMI (kg/m^2)	44.03 ± 3.62	41.77 ± 3.69 *	45.08 ± 5.78	0.016
Total cholesterol (mg/dL)	198.0 ± 27.77	183.6 ± 37.00	181.3 ± 36.58	0.700
Triglycerides (mg/dL)	196.0 ± 118.6	156.3 ± 78.26	121.8 ± 47.80	0.202
HDL cholesterol (mg/dL)	54.75 ± 13.91	47.13 ± 12.38	49.04 ± 12.59	0.484
LDL cholesterol (mg/dL)	104.0 ± 26.09	105.7 ± 29.38	107.8 ± 28.29	0.948
HOMA-IR	10.69 ± 4.46	10.15 ± 5.83	10.17 ± 6.00	0.199
A1C (%)	7.10 ± 1.09	6.91 ± 1.05	6.75 ± 1.11	0.712
Number with T2D (%)	5 (100%)	33 (80.5%)	23 (85.2%)	0.263
Number using insulin (%)	0 (0%)	5 (12.2%)	6 (22.2%)	0.538
Neck CIR (cm)	44.42 ± 3.38	45.35 ± 4.11	46.59 ± 5.11	0.433
Chest CIR (cm)	124.9 ± 9.34	127.5 ± 8.29 *	132.8 ± 8.89	0.025
Waist CIR (cm)	117.5 ± 11.21	120.3 ± 9.44	126.0 ± 11.39	0.617
Hip CIR (cm)	130.3 ± 13.56	130.7 ± 9.70 *	136.7 ± 9.64	0.047
Waist-to-hip ratio	0.899 ± 0.024	0.926 ± 0.067	0.925 ± 0.053	0.636
Torso VOL (L)	74.86 ± 17.24	74.08 ± 8.88	79.17 ± 11.61	0.156
Total body VOL (L)	126.0 ± 12.74	108.1 ± 12.02 *	118.4 ± 18.21	0.017
Body fat (%)	48.31 ± 9.91	51.50 ± 6.77	50.33 ± 6.00	0.534
Fat mass (kg)	70.45 ± 3.76	55.21 ± 9.59	59.13 ± 12.80	0.090
Lean mass (kg)	52.50 ± 9.43	51.39 ± 9.30 *	58.46 ± 9.81	0.026

Data are mean ± SD. ANOVA column reflects one-way analysis of variance testing between the three ethnic groups.

* p <0.05 for Tukey post-hoc analysis between Hispanic and African-American cohorts

** p<0.01 for Tukey post-hoc analysis between Hispanic and African-American cohorts. Abbreviations. CIR: circumference; HDL: high-density lipoprotein; LDL: low-density lipoprotein; VOL: volume.

Table 3.

Composition of the principal components (PC) in the cohort at baseline.

PC 1 Eigenvalue = 4.58	Factor Score	PC 2 Eigenvalue = 3.60	Factor Score	PC 3 Eigenvalue = 2.05	Factor Score	PC 4 Eigenvalue = 1.55	Factor Score	PC 5 Eigenvalue = 1.06	Factor Score
TV	0.944	Density	−0.910	Total Chol.	0.826	A1C	0.486	A1C	0.568
TBV	0.941	Body fat (%)	0.907	LDL Chol.	0.706	WHR	0.428	Triglycerides	−0.487
Chest CIR	0.849	Fat mass	0.907	Triglycerides	0.546	HDL Chol.	−0.419	HOMA-IR	0.476
Lean Mass	0.754	Hip CIR	0.620	HOMA-IR	0.455			HDL Chol.	0.446
Fat Mass	0.591	Lean Mass	−0.550						
WHR	0.493								
Neck CIR	0.481								
Hip CIR	0.404								

PC analysis of 3DPS variables and HOMA-IR resulted in three major PCs. Variables that composed a PC with a variable-component correlation >0.400 or <−0.400 are shown. Abbreviations. CIR: circumference; Chol.: cholesterol; TBV: total body volume; TV: torso volume; WHR: waist-to-hip ratio.

Table 4.

Effect of surgical weight loss on weight and 3DPS variables.

	Subjects Pre-RYGB	Subjects Pre-AGB	Δ (post-pre RYGB)	Δ (post-pre AGB)	P-value
N	34	9			
Female/Male	29/5	7/2			
Weight (kg)	115.6 ± 17.56	116.2 ± 9.61	−33.29 ± 11.30	−21.64 ± 13.16	0.011
Weight loss (%)			−28.79 ± 8.31	−18.41 ± 10.27	0.003
BMI (kg/m^2)	43.36 ± 4.41	43.16 ± 4.77	−12.28 ± 3.84	−8.02 ± 5.23	0.012
Total cholesterol (mg/dL)	181.5 ± 36.79	204.0 ± 38.11	−37.82 ± 44.69	−11.40 ± 35.40	0.241
Triglycerides (mg/dL)	158.4 ± 73.47	136.2 ± 77.18	−62.24 ± 59.45	−45.00 ± 78.81	0.601
HDL cholesterol (mg/dL)	45.59 ± 13.28	55.78 ± 14.16	6.75 ± 10.21	6.00 ± 14.89	0.899
LDL cholesterol (mg/dL)	104.2 ± 29.14	120.9 ± 27.78	−23.53 ± 9.40	−9.40 ± 25.74	0.275
HOMA-IR	10.43 ± 5.84	12.78 ± 8.16	−8.23 ± 5.03	−8.61 ± 6.00	0.847
A1C (%)	7.22 ± 1.21	6.66 ± 0.90	−1.64 ± 1.65	−0.70 ± 1.04	0.114
Number with T2D (%)	34 (100%)	9 (100%)	6 (17.6%)	3 (33.3%)	0.303
Number using insulin (%)	8 (23.5%)	0 (0%)	2 (5.9%)	0 (0%)	0.650
Neck CIR (cm)	46.95 ± 4.64	46.30 ± 5.64	−6.71 ± 3.98	−7.41 ± 7.72	0.722
Chest CIR (cm)	131.7 ± 10.64	127.4 ± 8.71	−23.42 ±19.59	−11.96 ± 7.39	0.095
Waist CIR (cm)	125.8 ± 11.49	122.7 ± 15.60	−25.78 ± 11.24	−16.83 ± 10.43	0.031
Hip CIR (cm)	132.2 ± 10.79	137.1 ± 10.65	−20.67 ± 7.27	−13.79 ± 7.54	0.016
Waist-to-hip ratio	0.953 ± 0.069	0.897 ± 0.099	−0.057 ± 0.060	−0.035 ± 0.059	0.338
Torso VOL (L)	80.37 ± 13.80	81.87 ±12.79	−26.57 ±8.42	−18.12 ± 9.52	0.013
Total body VOL (L)	116.3 ± 17.29	117.0 ± 11.29	−33.79 ± 9.76	−22.11 ± 12.28	0.004
Body fat (%)	49.80 ± 7.85	51.60 ± 9.29	−7.06 ± 8.27	−8.41 ± 4.21	0.640
Fat mass (kg)	57.17 ± 11.50	59.85 ± 13.71	−21.97 ± 10.56	−18.08 ± 9.00	0.319
Lean mass (kg)	58.05 ± 13.31	55.53 ± 10.02	−10.32 ± 7.56	−2.22 ± 5.40	0.005

Data are mean ± SD. Pre-surgery characteristics between RYGB and AGB subjects were not statistically different. P-value for comparison of change (Δ) between AGB and RYGB cohorts. Abbreviations. CIR: circumference; HDL: high-density lipoprotein; LDL: low-density lipoprotein, VOL: volume.