ORIGINAL POSTER

Body Composition with iDXA in Obese Subjects With and Without Metabolic Syndrome

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Introduction

Obesity has a major impact on public health and health-related expenses. Increased fat mass and its regional distribution, especially in the abdomen, are important predictors of the risk of cardiovascular disease and type-2 diabetes, diseases prevalent in individuals with a complex of metabolic risk factors referred to as the metabolic syndrome.

Methods

This study was approved by the Cedars Sinai Medical Center IRB. Sixty young (age 31.7 (6.9) years), obese subjects (33 females, 27 males) took part in an 8-month weight loss reality TV show. Fourteen participants received 3 months of televised “boot-camp” diet and exercise instruction and monetary incentives; thirty-six received only an intensive three-day diet and exercise seminar and weekly phone follow-up with no trainers or food services and negligible monetary awards; ten alternates received no instructions and were not invited back for the final assessment at 8-months. In addition to weight, blood pressure, anthropometric variables (waist circumference, hip circumference, waist/hip ratio), a number of metabolic variables (fasting glucose, high density lipoproteins (HDL), triglycerides), and body composition variables (android %fat, gynoid %fat, android/gynoid %fat ratio, trunk %fat, and total body %fat and %lean) were recorded at baseline and eight months later at the conclusion of the fitness program.

Body composition variables were calculated automatically by dual-energy x-ray absorptiometry (Lunar iDXA, GE Healthcare). Subjects whose supine body width exceeded the dimensions of the scan window were measured using the iDXA MirrorImage™ application (Figure 1a), which automatically calculates total body (TB) results by doubling the half-body values. Previous studies have shown that this doubling method provides an accurate estimate of TB results [1,2]. The android region included an area from the top of the iliac crest to 20% of the distance from the iliac crest to the bottom of the subject’s head (Figure 1b). The gynoid region extended from the top of the greater trochanter down a distance twice the height of the android region. All iDXA %fat values were calculated as %fat = fat mass/(fat mass + lean mass + bone mass), also known as “region %fat.” The iDXA %lean values were calculated as %lean = lean mass/(fat mass + lean mass + bone mass). Waist circumference (WC) was measured at the umbilicus, parallel to the floor, upon exhalation.

Metabolic syndrome (MS) was diagnosed, following the American Heart Association/National Heart Lung And Blood Institute (AHA/NHLBI) guidelines, in subjects who had at least three of the following criteria: a) WC > 35 inches (88.9 cm) for females and > 40 inches (101.6 cm) for males, b) fasting glucose > 100 mg/dL, c) triglycerides > 150 mg/dL, d) HDL < 50 mg/dL for females and <40 mg/dL for males, e) systolic blood pressure > 130 mm Hg or diastolic blood pressure >85 mm Hg. Student’s t-tests were used to determine significance differences between those with and those without MS.

Figure 1. Body composition measurement with iDXA

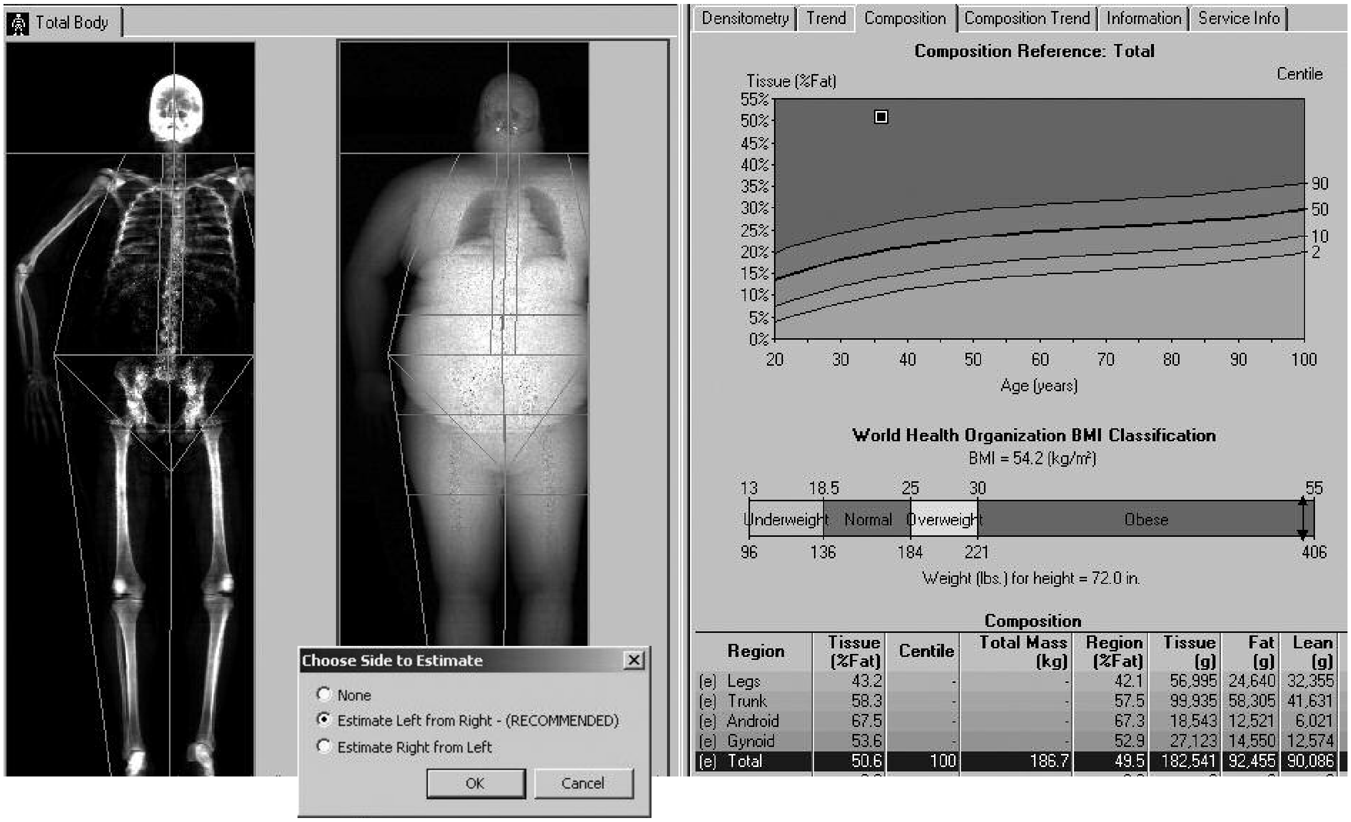


Figure 1a. Total body MirrorImage feature with 187 kg male subject (above); color imaging of 130 kg female (right)

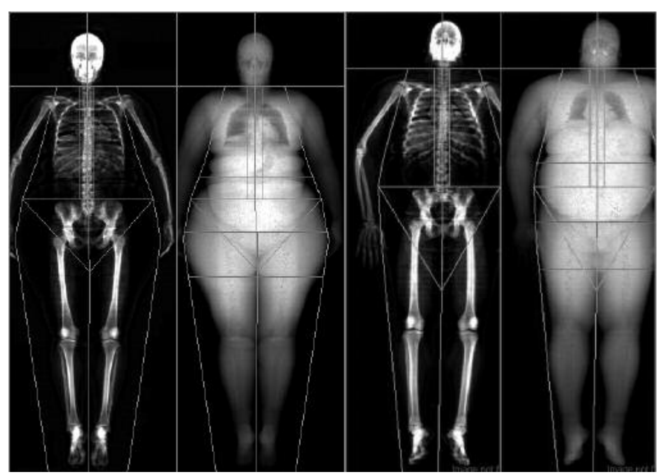


Figure 1b. Android and gynoid regions on 110kg female (left) and 168 kg male (right)

Results

The average (SD) age, height, weight, and BMI for females at baseline were 30.4 yr (6.4), 165.6 cm (5.0), 110.3 kg (10.3), and 40.2 m/kg^2 (3.7), respectively. The average (SD) age, height, weight, and BMI for males at baseline were 33.9 yr (7.3), 182.7 cm (7.0), 156.8 kg (18.5), and 46.9 m/kg^2 (4.6), respectively. Based on the presence of three or more risk factors for MS, 13 of the 33 females and 24 of 27 males had MS at the start of the program. Forty-nine of the fifty active participants (27 females, 22 males) were evaluated again at 8 months for the program finale.

Women's Body Composition

- Body composition variables for women at baseline with and without MS are shown in Table 1. Variables were generally not significantly different between those with and without MS. Waist/hip ratio (WHR) was significantly higher in the MS group.
- Body composition variables for the 27 women at 8 months are shown in Table 2. Only one of the 13 women with MS at the beginning of the program had MS at the end, thus precluding statistical analysis in this group.
- The changes in variables for females (n = 27) over the course of the study are shown in Table 3. Women lost an average of 28.2 kg of weight, 22.4 cm of WC, and 20.6 cm of hip circumference (HC). Android and gynoid fat decreased by ~20% and ~14%, respectively. Trunk %fat and TB %fat decreased by ~17% and ~14%, respectively, while TB %lean increased by ~14%. The average change in bone mineral content (BMC) was negligible (-20.1 g or <1%).

Table 1. Mean (SD) values for female subjects (n = 33) with and without metabolic syndrome at baseline

Metabolic Syndrome	Weight (kg)	BMI (m/kg^2)	Waist Circ (cm)	Hip Circ (cm)	Waist/Hip Ratio	Android %Fat	Gynoid %Fat	A/G %Fat Ratio	Trunk %Fat	TB %Fat	TB %Lean	BMC (g)
Yes n = 13	113.1 (11.2)	40.3 (4.5)	131.6 (10.2)	131.5 (9.0)	1.00 (0.05)	61.3% (5.3%)	57.7% (3.9%)	1.06 (0.05)	53.2 4.9%	48.9% (4.3%)	49.8% (4.3%)	2833 (331)
No n = 20	108.4 (9.4)	39.9 (3.0)	124.8 (10.1)	131.8 (9.2)	0.95 (0.07)	62.2% (5.4%)	59.7% (5.0%)	1.05 (0.10)	52.9% (5.1%)	52.9% (5.1%)	48.9% (4.1%)	2769 (190)
P Value	0.22	0.56	0.07	0.11	0.02*	0.63	0.21	0.53	0.86	0.67	0.53	0.54

* p<0.05

Table 2. Mean (SD) values for female subjects with and without metabolic syndrome after weight loss program

Metabolic Syndrome	Weight (kg)	BMI (m/kg^2)	Waist Circ (cm)	Hip Circ (cm)	Waist/Hip Ratio	Android %Fat	Gynoid %Fat	A/G %Fat Ratio	Trunk %Fat	TB %Fat	TB %Lean	BMC (g)
Yes n=1	181.2	33.2	114.3	118.1	0.97	52.2%	50.4%	1.04	46.7%	43.1%	43.3%	2529
No n=26	180.5 27.1	29.7 (4.7)	101.1 (13.6)	110.7 (12.1)	0.92 (0.06)	42.2% (14.2%)	44.9% (8.9%)	0.92 (0.21)	35.9% (11.2%)	35.0% (8.9%)	63.8% (9.1%)	2745 (236)

Table 3. Change in values in female subjects (n = 27) after weight loss program

Change	Weight (kg)	BMI (m/kg^2)	Waist Circ (cm)	Hip Circ (cm)	Waist/Hip Ratio	Android %Fat	Gynoid %Fat	A/G %Fat Ratio	Trunk %Fat	TB %Fat	TB %Lean	BMC (g)
Mean (SD)	-28.2 (12.5)	-10.3 (4.6)	-22.4 (28.0)	-20.6 (12.1)	-0.3 (0.2)	-19.7% (13.9%)	-13.8% (8.9)	-0.13 (0.17)	-17.3% (11.2)	-14.4% (9.0)	13.5% (8.6%)	-20.1 (48.6)
% (SD)	-25.3% (10.3%)	-25.3% (10.3%)	-20.9% (10.3%)	-15.5% (8.5%)								-0.7% (1.8%)

Men's Body Composition

- Body composition variables for men at baseline with and without MS are shown in Table 4. Only 3 of 27 men did not have MS at baseline. Variables were generally not significantly different between those with and without MS. As in females, WHR was significantly higher in the male MS group. The android/gynoid %fat ratio was also significantly higher in males with MS.
- Body composition variables for men with and without MS at 8 months are shown in Table 5. Nineteen of the 24 men with MS at baseline were assessed at 8 months. The 3 men without MS at baseline remained without MS at 8 months. Five of the 24 subjects with MS at baseline were not evaluated at 8 months. Five men with MS at baseline completed the program and continued to have MS at 8 months, while 14 of them improved after completing the program to the point of no longer having MS. The five men with MS at 8 months showed significant differences in body composition compared to those without MS. Several anthropometric variables, including WC (124.3 vs. 102.0 cm), HC (122.8 vs. 106.2 cm), and WHR (1.01 vs. 0.96) were significantly higher in subjects with MS. Also, android %fat (48.1% vs. 25.8%), A/G %fat ratio (1.35 vs. 0.96), trunk %fat (40.9% vs. 22.5%) and TB %fat (34.9% vs. 20.9%) were significantly higher in subjects who continued to have MS at 8 months compared to those without MS. Total body %lean values were significantly lower (64.1% vs. 78.3%) in men with MS.
- The changes in men over the course of the study are shown in Table 6. The men's losses were even more impressive than the women's losses. Men lost an average of 49.3 kg of weight, 35.0 cm of WC, and 25.9 cm of HC. Android and gynoid fat decreased by ~31% and ~20%, respectively. Trunk %fat and TB %fat decreased by ~26% and ~20%, respectively, while TB %lean increased by 19%. The average change in BMC was negligible (-35 g or about 1%).

Table 4. Mean (SD) values for male subjects (n = 27) with and without metabolic syndrome at baseline

Metabolic Syndrome	Weight (kg)	BMI (m/kg^2)	Waist Circ (cm)	Hip Circ (cm)	Waist/Hip Ratio	Android %Fat	Gynoid %Fat	A/G %Fat Ratio	Trunk %Fat	TB %Fat	TB %Lean	BMC (g)
Yes n=24	157.0 (18.9)	47.1 (4.5)	143.2 (8.0)	136.0 (8.5)	1.06 (0.05)	61.9% (3.9%)	46.6% (5.0%)	1.34 (0.12)	53.2% (3.8)	44.7% (3.9%)	54.1% (3.9%)	3910 (450)
No n=3	147.9 (15.2)	43.9 (4.9)	137.2 (6.2)	138.3 (8.0)	0.99 (0.02)	60.2% (4.4%)	51.6% (2.6%)	1.16 (0.05)	50.3% (4.7)	43.7% (5.3%)	55.1% (5.4%)	3885 (460)
P Value	0.45	0.39	0.26	0.47	0.006*	0.59	0.054	0.007*	0.42	0.78	0.79	0.94

* p<0.01

Table 5. Mean (SD) values for male subjects (n = 22) with and without metabolic syndrome after weight loss program

Metabolic Syndrome	Weight (kg)	BMI (m/kg^2)	Waist Circ (cm)	Hip Circ (cm)	Waist/Hip Ratio	Android %Fat	Gynoid %Fat	A/G %Fat Ratio	Trunk %Fat	TB %Fat	TB %Lean	BMC (g)
Yes n=5	127.3 (23.9)	38.4 (6.3)	124.3 (12.7)	122.8 (10.8)	1.01 (0.02)	48.1% (12.0%)	36.0% (10.4%)	1.35 (0.10)	40.9% (10.6)	34.9% (9.8%)	64.1% (9.9%)	3750 (649)
No n=17	100.3 (20.3)	30.9 (6.0)	102.0 (13.7)	106.2 (11.4)	0.96 (0.05)	25.8% (15.7%)	25.7% (10.9%)	0.96 (0.30)	22.5% (12.1)	20.9% (9.3%)	78.3% (9.6%)	3929 (427)
P Value	0.71	0.39	0.015*	0.024*	0.004**	0.009**	0.08	0.0002**	0.013*	0.03*	0.03*	0.59

* p<0.05, **p<0.01

Table 6. Change in values in male subjects (n = 22) after weight loss

Change	Weight (kg)	BMI (m/kg^2)	Waist Circ (cm)	Hip Circ (cm)	Waist/Hip Ratio	Android %Fat	Gynoid %Fat	A/G %Fat Ratio	Trunk %Fat	TB %Fat	TB %Lean	BMC (g)
Mean (SD)	-49.3 (20.2)	-14.7 (5.7)	-35.0 (15.0)	-25.9 (13.8)	-0.07 (0.05)	-30.7% (16.8%)	-19.8% (12.7%)	-0.28 (0.28)	-26.1% (12.8%)	-20.3% (10.0%)	19.1% (9.4%)	-35.0 (88.8)
% (SD)	-31.7% (11.9%)	-31.7% (11.9%)	-24.5% (10.4%)	-18.9% (9.5%)								-1.0% (2.3%)

Figure 2 shows the percent change of various variables in men and women from baseline to the end of the program. Males lost a larger percentage of their baseline values than women, albeit both males and females showed dramatic changes over the 8 months of the study. BMC showed only slight losses (<1%) with weight loss.

Males with metabolic syndrome (n = 5) at the end of the weight loss program showed significantly less change in anthropometric and body composition variables than males without the syndrome (n = 17) at the end of the weight loss program (Table 7, Figure 3).

Figure 2. Change in anthropometric and body composition variables in males and females after weight loss program (n=49)

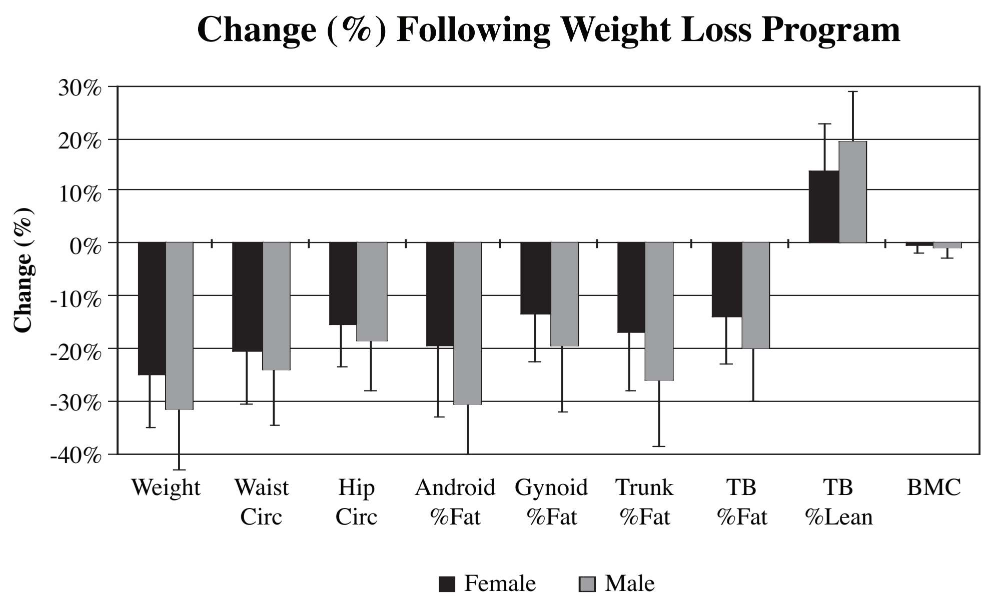


Table 7. Change in anthropometric and body composition variables among 22 men with and without metabolic syndrome

	With Metabolic Syndrome (n = 5)	Without Metabolic Syndrom (n = 17)	p value
Weight	-21.2%	-34.7%	<0.01
Waist Circumference	-12.8%	-27.9%	<0.01
Hip Circumference	-8.8%	-21.8%	<0.001
Android %fat	-13.9%	-35.7%	<0.001
Gynoid %fat	-8.0%	-23.3%	<0.01
Trunk %fat	-13.0	-29.9%	<0.01
Total Body %fat	-10.2%	-23.3%	<0.01
Total Body Fat (kg)	-27.2	-44.5	<0.01
Total Body %lean	9.6%	22.0%	<0.01
Total Body Lean (kg)	-6.4	-5.6	ns

Figure 3. Change in anthropometric and body composition variables among 22 men with and without metabolic syndrome

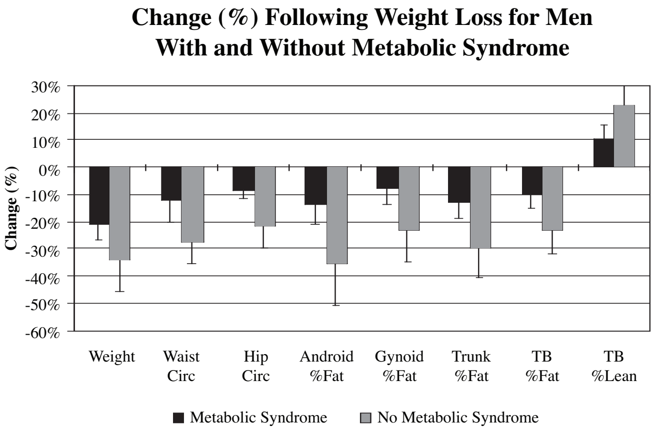
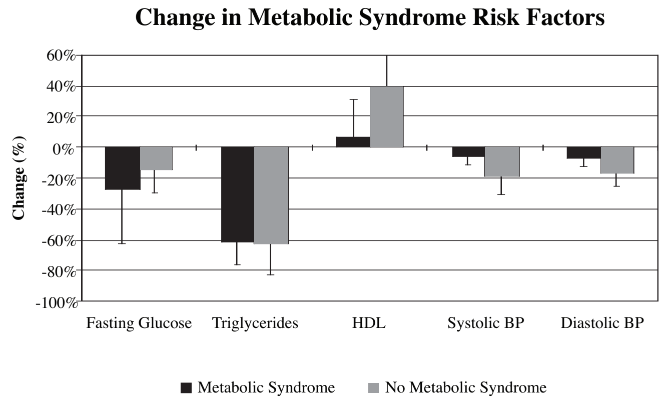


Figure 4. Change in metabolic syndrome risk factors for males (n=22) with and without metabolic syndrome



In addition to WC, several blood related variables were used to distinguish subjects with and without MS. Figure 4 shows the change in these blood-related risk factors for men with and without MS at 8 months. The larger changes for those without MS at 8 months were expected given that these were among the variables used to diagnose MS. Noticeable was the similarity in change in triglycerides, with both groups reducing triglycerides by close to 60%.

Bone Mineral Density

- Total body bone mineral density (BMD), BMC, and Area showed negligible changes following the large weight loss (females 28.2 kg, males 49.3 kg) in these highly obese subjects (females 110.3 kg (10.0); males 155.8 (19.5) kg at baseline) who completed the 8-month program.

Table 8. Percent change (SD) in bone variables for females and males after weight loss program

	BMC	Area	BMD
Female Subjects n=27	0.7% (1.8%)	-0.3% (1.9%)	-0.4% (1.5%)
Male Subjects n=22	-1.0% (2.3%)	-0.1% (1.9%)	-0.8% (2.6%)

Discussion

- Baseline results for this convenience sample of predominantly morbidly obese (BMI>40) subjects showed no significant differences in anthropometric and body composition variables among women with and without MS, while men showed significant differences only for WHR and android/gynoid ratio. These measurements indicated the importance of the waist-to-hip comparison in differentiating men with and without MS in this population. This finding of abdominal dominance might be expected, given that WC is one of the six criteria used to indicate presence of MS, but all subjects had WC values that met the criteria for MS, so the higher levels in those with MS were notable.
- The relative insensitivity of baseline measurements to distinguish between men and women with and without MS might be attributed to the fact that all subjects were very obese and thus exhibited relatively limited variability of key body composition and MS criteria. Also, only 3 of 27 men did not have MS at baseline, thus limiting statistical analysis of this group. Finally, sensitivity of WC has been shown to have little added predictive power of disease risk beyond BMI for subjects with BMI>35; all but 3 subjects (all female) exceeded this BMI at baseline [3].
- Following the intense weight loss program, 27 of the original 33 women were evaluated at 8 months. Twelve of the original 13 women who met MS criteria at baseline no longer had MS at 8 months, leaving just one of the remaining 27 women with MS. Thus, no further statistical analysis of this sample in relation to MS was warranted.
- Of the original 27 men, 22 were present at the 8-month assessment. Of these, five had MS both at baseline and at 8 months. Fourteen men with MS at baseline improved to the point where they no longer met the MS criteria at 8 months. Even the 5 men who remained with

Discussion (continued)

MS at the end of the program showed marked improvement in many areas, including a roughly 8% to 15% loss in WC and HC, android %fat, gynoid %fat, TB %fat and trunk %fat. These improvements, however, were not sufficient to remove these men from the diagnosis of MS and were overshadowed by the much larger -20% to -36% changes in anthropometric and body composition variables shown by those without MS at the end of the study. These differences in losses between those with and without MS at 8 months were all statistically significant ($p<0.01$). The percent of weight lost as fat was 80.7% for those men with MS and 92.4% for those men without MS at 8 months. The largest loss among those without MS at 8 months was in android %fat (-36%), an indication of truly substantial loss of fat around the abdomen, the area felt to be a key indicator of MS.

- The overall amount of change among participants in this study was remarkable. Subjects completing the study lost 25% (female) and 32% (male) of their weight, and reduced their WC by 21% (female) and 24% (male). Female subjects decreased their android (abdominal) fat by nearly a third from 62% at baseline to 43% at 8 months; males decreased android %fat by half from 62% at baseline to 31% at 8 months. Total body %fat decreased by nearly a third in females and nearly half in males: women's average TB %fat decreased from 49% at baseline to 35% at 8 months, and men's decreased from 45% at baseline to 24% at 8 months. The women and men evaluated at 8 months lowered their A/G ratio from 1.05 and 1.32, respectively, at baseline to 0.92 and 1.05, respectively, at the end of the study. For men evaluated at 8 months, 89% of their weight loss was fat, while the percent of weight lost as fat was 90% for women.
- Change in TB bone variables (BMC, Area, BMD) following the weight loss program in these obese subjects was negligible (≤1%). Previous studies [4,5] have suggested that DXA measurement of bone mass in obese subjects might be compromised by the potentially negative effects of increased soft tissue thickness and increased x-ray attenuation on accurate bone edge detection. The negligible effect on bone variables observed in this population of extremely thick subjects might be attributed to enhanced edge detection and image quality previously noted with the iDXA [6,7]. The iDXA utilizes greater x-ray flux and a high-definition detector for improved performance in obese subjects.

Conclusion

Regional DXA fat measurements in this convenience sample of very obese men, including the android/gynoid ratio, waist measurements, and waist to hip ratios were significant predictors of metabolic syndrome in this study of subjects enrolled in a reality TV weight loss program. We were unable to make similar conclusions with women due to the lack of women without metabolic syndrome at baseline and the lack of women with metabolic syndrome at the conclusion of the weight loss program.

References

1. Hans D, Genton L, Conicella G, Karsegard V, Pichard C, Slosman D (2001) Half-body DXA scan predicts whole body composition: a potential method to measure overweight patients. Clin Nutr 20 (Suppl 3):1.
2. Tataranni PA, Ravussin E (1995) Use of dual-energy X-ray absorptiometry in obese individuals. Am J Clin Nutr 62:730-734.
3. National Heart Lung and Blood Institute Guidelines www.nhlbi.nih.gov/guidelines/obesity/e_txtbk/txgd/4142.htm
4. Blake GM, Herd RJM, Patel R, Fogelman I (2000) The effect of weight change on total body dual-energy X-ray absorptiometry: Results from a clinical trial. Osteoporos Int 11:832-839
5. Compston JE, Laskey MA, Croucher PI, Coxon A, Kreitzman S (1992) Effect of diet-induced weight loss on total body bone mass. Clin Sci: 82:429-432
6. O'Connor MK, Enright, D (2006) Performance of the Lunar iDXA Imaging Densitometer in normal and obese subjects. Calcif Tissue Int 78 (Suppl 1):S150.
7. O'Connor (2006) Abdominal thickness and its impact on the accuracy of bone densitometry measurements with the Lunar iDXA scanner. Osteoporos Int 17 (Suppl 2): S289.