

## Effect of ethnicity on weight loss among adolescents 1 year after bariatric surgery

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weight outcomes vary by ethnicity in a large, nationally representative sample of adolescents.

**METHODS:** The Bariatric Outcomes Longitudinal Database was used for analysis and contains data on surgeries performed on adolescents from 2004 to 2010 from 423 surgeons at 360 facilities across the United States Adolescents ( $n = 827$ ) between 11 and 19 years old who underwent either gastric bypass or adjustable gastric banding surgery were included in the analysis. Outcome measures included changes in anthropometric measurements [weight (kg) and body mass index] from baseline to 3 ( $n = 739$ ), 6 ( $n = 512$ ), and 12 ( $n = 247$ ) mo after surgery.

**RESULTS:** A year after patients underwent either gastric bypass (51%) or adjustable gastric banding (49%) surgery, mean estimated weight loss for all ethnic groups differed by a maximum of only 1.5 kg, being 34.3 kg (95%CI: 30.0-38.5 kg) for Hispanics, 33.8 kg (95%CI: 27.3-40.3 kg) for non-Hispanic blacks, and 32.8 kg (95%CI: 30.9-34.7 kg) for non-Hispanic whites. No overall pairwise group comparisons were significant, indicating that no ethnic group had better weight loss outcomes than did another.

**CONCLUSION:** Bariatric surgery substantially reduces the weight of severely obese adolescents at 1 year post-procedure with little variation by ethnicity and/or gender. These results suggest that bariatric surgery is a safe and reasonable treatment for all severely obese adolescents with the appropriate indications.

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**Key words:** Bariatric surgery; Gastric bypass surgery; Adjustable gastric band surgery; Adolescents; Severe obesity; Ethnicity; Weight loss

**Core tip:** Bariatric surgery is one of the few effective

### Abstract

**AIM:** To investigate whether or not bariatric surgery

treatments for severe obesity. Among adults, outcomes of bariatric surgery differ by ethnicity. We tested whether this relationship is also true among adolescents. Outcome measures included changes in anthropometric measurements (weight and body mass index) from baseline ( $n = 827$ ) to 1 year after surgery. Our results support the conclusion that bariatric surgery can substantially reduce weight in severely obese adolescents for at least 1 year, irrespective of their race or ethnicity. Ethnicity is a reasonable and safe treatment for all severely obese adolescents with the appropriate indications.

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## INTRODUCTION

The Centers for Disease Control and Prevention (CDC) recently reported that the prevalence of childhood obesity in the United States has stabilized over the past few years, although it remains high among all age, sex, and ethnic groups<sup>[1]</sup>. An estimated 12% of all United States children between 2 and 19 years old have a body mass index (BMI)  $\geq 97^{\text{th}}$  percentile for age and sex. Moreover, the prevalence of obesity differs significantly among racial and ethnic groups. In 2009-2010, 21% of Hispanic and 24% of non-Hispanic black children and adolescents were obese, whereas 14% of non-Hispanic white children and adolescents were obese.

Childhood obesity has several health-related consequences that, until recently, were documented only in adulthood, including hypertension, insulin resistance, glucose intolerance, and dyslipidemia<sup>[2]</sup>. In turn, these conditions are risk factors for type 2 diabetes and cardiovascular disease in both childhood and adulthood<sup>[3-5]</sup>. Weight-loss surgery among both adults and adolescents has become increasingly recognized as effective treatment for severe obesity and several of its related comorbidities<sup>[6-10]</sup>. Current studies suggest that neither pharmacologic nor dietary treatment can maintain weight loss in obese adolescents as effectively as can weight-loss surgery<sup>[11,12]</sup>.

Several studies have shown that among adults, weight loss outcomes after bariatric surgery differ by ethnicity with some studies reporting better outcomes among non-Hispanic whites than among non-Hispanic blacks<sup>[13-16]</sup>. Although the literature on outcomes of bariatric surgery in adolescents has increased exponentially, many studies are small and usually from single institutional series<sup>[8]</sup>. As a result, patients are not geographically or ethnically diverse, despite the fact that obesity disproportionately affects ethnic minorities<sup>[1]</sup>.

Accordingly, we analyzed data from the Bariatric Outcomes Longitudinal Database (BOLD), a large national database that tracks outcomes in patients from a wide geographical area who have undergone bariatric surgery. We report here the results of our analysis, which indicate that weight loss in a large cohort of severely obese adolescents 1 year after bariatric surgery did not differ by ethnicity.

## MATERIALS AND METHODS

### BOLD database

Data for the BOLD database are collected prospectively from participants in the Bariatric Surgery Center of Excellence (BSCOE) program sponsored by the American Society for Metabolic and Bariatric Surgery (ASMBS)<sup>[17]</sup>. Participating centers enter data collected on all bariatric surgery patients during preoperative visits, the hospital stay, and all postoperative visits. These data are used to monitor adherence to the requirements of the BSCOE program and to support quality assessments for the surgical treatment of obesity and its associated conditions.

All BSCOE programs undergo a site inspection before approval and recertification every 3 years. During the site inspection, the accuracy of BOLD data is verified in an impartially selected sample of 10% of medical records. All data on complications and readmissions are also reviewed for accuracy. To ensure accurate data input, any discrepancies result in a mandatory review of all charts at that center.

### Research data

The Copernicus Group Independent Review Board (Durham, NC) approved the use of BOLD data for research. The BOLD study has been registered with the National Institutes of Health (clinical trial #NCT01002352). Informed consent was obtained from all parents and assent was obtained from all patients.

About 65% (169000) of patients treated by surgeons participating in the BSCOE program have allowed their data to be analyzed for research purposes. Preliminary analyses show that the demographic characteristics of patients included in the database do not differ substantially from those who are not<sup>[17]</sup>. Data are currently entered into the database by more than 1000 surgeons from more than 600 facilities in the United States (all states are represented with the exception of Vermont and New Mexico), representing approximately 85% of all facilities nationwide performing at least 10 bariatric procedures per year.

### Patient selection

We analyzed data from all patients 11 to 19 years old who had undergone bariatric surgery between April 2004 and October 2010 (the most current data available for analysis) who allowed their data to be used for research purposes. The data analyzed here came from 360 facilities and 423 surgeons participating in the BSCOE program.

All patients had met the National Institutes of Health criteria for bariatric surgery<sup>[18]</sup>. Thus, all patients had a BMI > 35 kg/m<sup>2</sup> and ≥ 1 co-morbidity (*e.g.*, elevated blood pressure, hypercholesterolemia) or a BMI > 40 kg/m<sup>2</sup>.

### Data collection

We collected data on age, sex, race/ethnicity, weight (kg), BMI, and weight loss, calculated as the difference between the weight before surgery and the weight at each respective time point.

Intraoperative data used in the present analysis consisted of the procedure (gastric bypass or adjustable gastric band) and the date of surgery. The primary outcomes were weight loss measured by various anthropometric measures and consisted of age- and sex-adjusted BMI percentiles as well as crude BMI and weight (kg)<sup>[19]</sup>. Data were collected before surgery and at 3, 6 and 12 mo after surgery.

Because not all patients had their follow-up appointment exactly at these times, the 3-mo data collection point included data collected from 0 to 3 mo after surgery, the 6-mo time point consisted of data collected from 3 to 9 mo after surgery, and the 12-mo time point consisted of data collected 9 to 15 mo after surgery.

### Statistical analysis

To assess changes in weight and BMI, separate repeated-measures, linear mixed-models were fit using the MIXED procedure in SAS version 9.2 (SAS Institute, Inc., Cary, NC, United States). A compound symmetric variance-covariance matrix was selected for each model to account for the correlation of within-patient repeated observations. Age at surgery, sex, surgery type (gastric bypass or adjustable gastric band), and time period of data collection were the fixed covariates considered for potential inclusion in each model; patients were considered to be a random variable. Because the sample was so skewed in terms of distribution of BMI percentile (the majority of patients had a BMI at or above the 99<sup>th</sup> percentile, the clinical definition of “severe obesity” before surgery) and because the literature consistently reports that comorbidities intensify and multiply with increased weight<sup>[4,5]</sup> we also analyzed the results for three categories defined by baseline BMI values: 35.0–49.0 kg/m<sup>2</sup>; 50.0–59.99 kg/m<sup>2</sup>; and greater than 60.0 kg/m<sup>2</sup>.

Patients may not have been eligible for follow-up analysis if they had surgery shortly before the analysis: 89% of eligible patients were seen at 3 mo ( $n = 739$ ), 62% at 6 mo ( $n = 512$ ), and 30% ( $n = 247$ ) at 12 mo after surgery. Those identified as “other” are not included in the denominator or the follow-up analysis as a result of the small sample size.

Because of potential selection bias caused by losses to follow-up, we tested for any selection bias between the whole sample ( $n = 890$ ) and those patients for which data from all four time-points were available ( $n = 247$ ) using the mixed-model approach described below and by including an indicator variable for complete or incomplete

**Table 1** Characteristics of 890 adolescents who underwent bariatric surgery between 2004 and 2010

Characteristic	<i>n</i> (%)	Baseline BMI Z score, mean ± SD	<i>P</i>
Sex			< 0.001
Boys	225 (25.3)	3.14 ± 0.24	
Girls	665 (74.7)	2.41 ± 0.19	
Type of surgery			< 0.001
Gastric bypass	454 (51.0)	2.67 ± 0.38	
Adjustable gastric band	436 (49.0)	2.53 ± 0.36	
Race			
Non-hispanic white	606 (68.1)	2.57 ± 0.37	Reference
Hispanic	129 (14.5)	2.68 ± 0.40	0.004 <sup>1</sup>
Non-hispanic black	98 (11.0)	2.67 ± 0.34	0.02 <sup>2</sup>
Other	57 (6.4)	2.60 ± 0.42	

<sup>1</sup>Non-Hispanic white *vs* Hispanic; <sup>2</sup>Non-Hispanic white *vs* non-Hispanic black. BMI: Body mass index.

data<sup>[20]</sup>. Results showed that the two samples did not differ on baseline BMI or weight outcomes or between the proportion of males and females. This finding supports the external validity of our overall conclusions.

In a mixed model, the particular levels of fixed-effects are of interest, and inferences are made for those specific levels; random-effects are considered to be random samples from the population, and inferences are not made to a specific sample but to the entire population. The interaction between time and ethnicity was also assessed. A planned-comparisons approach was used to evaluate changes between ethnic groups because mean baseline BMI values differed significantly. Contrasts were used to test for differences between groups at each time for mean values of weight and BMI. *Alpha* was set at 0.05.

## RESULTS

Of the 890 eligible adolescents, 75% were females (mean age, 18.5 years 68% were white non-Hispanic, 15% were Hispanic, 11% were non-Hispanic black, and 6% were “other” (Table 1). Gastric bypass surgery was performed in 51% of the patients, and gastric band surgery in 49%. At baseline, males were significantly heavier than females. Those undergoing gastric bypass surgery were significantly heavier than those undergoing adjustable gastric band surgery. Non-Hispanic whites were significantly lighter than their ethnic group counterparts (Table 1). Because of these significant baseline differences in sex and surgery type, all subsequent analyses are adjusted for these variables.

All anthropometric measures significantly decreased in non-Hispanic whites and Hispanics throughout the 1 year follow-up period (Table 2). Among both non-Hispanic whites and Hispanics, mean BMI percentile decreased to just below non-obese levels 1 year after surgery (94.67<sup>th</sup> percentiles for both groups, respectively).

When the sample was stratified by sex the variation among ethnic groups was only 3.7 kg for girls and 10 kg for boys (Tables 3 and 4). Further analysis revealed no

**Table 2** Estimated anthropometric values of morbidly obese adolescents at baseline to 1 year after bariatric surgery by ethnicity

Measurement	Non-hispanic whites, estimate (95%CI)	Non-hispanic blacks, estimate (95%CI)	Hispanics, estimate (95%CI)	Overall, estimate <sup>1</sup> (95%CI)
Baseline				
<i>n</i>	601	98	128	827
BMI (kg/m <sup>2</sup> )	47.9 (47.3-48.4)	51.7 (50.1-53.4)	48.9 (47.7-50.2)	48.5 (48.0-49.0)
BMI (%)	99.3 (99.2-99.4)	99.5 (99.4-99.6)	99.4 (99.3-99.5)	99.4 (99.3-99.4)
Weight (kg)	136.8 (135.0-138.6)	147.9 (142.5-153.3)	137.7 (134.1-141.3)	138.4 (136.8-140.0)
3 mo after surgery				
<i>n</i>	536	88	115	739
BMI (kg/m <sup>2</sup> )	43.9 (43.4-44.5)	47.9 (46.4-49.4)	44.5 (43.3-45.6)	44.48 (43.98-44.97)
BMI (%)	99.0 (98.0-99.1)	99.3 (99.2-99.4)	99.1 (99.0-99.2)	99.02 (98.96-99.08)
Weight (kg)	125.6 (123.9-127.4)	137.0 (132.0-141.9)	125.1 (121.7-128.4)	126.84 (125.33-128.35)
EWL (kg)	10.7 (10.1-11.3)	10.57 (9.11-12.04)	12.3 (10.5-14.1)	10.9 (10.4-11.5)
EWL (%)	7.8 (7.3-8.2)	6.9 (6.0-7.8)	8.6 (7.4-9.7)	7.8 (7.4-8.2)
6 mo after surgery				
<i>n</i>	380	54	78	512
BMI (kg/m <sup>2</sup> )	39.0 (38.3-39.7)	44.1 (42.4-45.7)	39.9 (38.5-41.2)	39.70 (39.1-40.3)
BMI (%)	97.0 (96.5-97.5)	98.9 (98.6-99.1)	97.8 (97.3-98.3)	97.3 (96.9-97.7)
Weight (kg)	111.7 (109.7-113.7)	125.7 (120.4-131.0)	111.9 (108.2-115.6)	113.3 (111.6-115.0)
EWL (kg)	25.1 (24.1-26.0)	22.3 (19.7-25.0)	25.4 (22.8-28.0)	24.8 (23.9-25.7)
EWL (%)	18.3 (17.66-19.0)	14.5 (12.9-16.1)	18.1 (16.2-19.9)	17.8 (17.2-18.4)
12 mo after surgery				
<i>n</i>	193	26	28	247
BMI (kg/m <sup>2</sup> )	36.6 (35.7-37.4)	40.3 (37.5-43.0)	36.7 (34.7-38.8)	37.0 (36.3-37.8)
BMI (%)	94.7 (93.6-95.7)	96.8 (94.3-99.2)	94.7 (92.2-97.2)	94.9 (94.0-95.8)
Weight (kg)	104.6 (102.1-107.0)	114.7 (106.4-123.0)	103.1 (97.3-109.0)	105.6 (103.4-107.8)
EWL (kg)	32.8 (30.9-34.7)	33.8 (27.3-40.3)	34.3 (30.0-38.5)	33.1 (31.4-34.82)
EWL (%)	23.6 (22.3-24.9)	21.6 (17.4-25.7)	24.7 (21.8-27.7)	23.5 (22.4-24.7)

Model adjusted by age, sex, and type of surgery; "Other" group not included as result of a small sample size. EWL: Estimated weight loss or the difference between baseline weight (kg) and weight as each respective time point; <sup>1</sup>*P* < 0.001 for change across all time points. BMI: Body mass index.

**Table 3** Estimated anthropometric values from morbidly obese boys 1 year after bariatric surgery by ethnicity

Measurement	Non-hispanic whites, estimate (95%CI)	Non-hispanic blacks, estimate (95%CI)	Hispanics, estimate (95%CI)	Overall, estimate <sup>1</sup> (95%CI)
Before surgery				
<i>n</i>	142	23	42	207
BMI (kg/m <sup>2</sup> )	51.2 (49.8-52.7)	52.3 (49.0-55.5)	52.8 (50.8-54.9)	51.68 (50.53-52.84)
BMI (%)	99.9 (99.6-100.0)	99.9 (99.8-100.0)	99.9 (99.8-100.0)	99.9 (99.8-100.0)
Weight (kg) <sup>2</sup>	162.4 (158.0-166.7)	166.7 (155.3-178.2)	161.8 (155.8-167.8)	162.8 (159.3-166.3)
3 mo after surgery				
<i>n</i>	127	21	38	186
BMI (kg/m <sup>2</sup> )	46.9 (45.5-48.3)	47.5 (44.8-50.2)	47.1 (45.2-48.9)	46.9 (45.9-48.1)
BMI (%)	99.7 (99.6-99.8)	99.9 (99.7-99.9)	99.8 (99.7-99.9)	99.8 (99.7-99.9)
Weight (kg) <sup>2</sup>	148.5 (144.1-152.8)	151.7 (141.7-161.7)	144.3 (138.6-149.9)	148.0 (144.5-151.4)
EWL (kg) <sup>2</sup>	13.2 (11.7-14.6)	14.4 (10.9-17.9)	17.3 (13.3-21.3)	14.1 (12.8-15.4)
EWL (%)	8.1 (7.3-8.9)	8.5 (6.6-10.3)	10.4 (8.2-12.6)	8.6 (7.9-9.4)
6 mo after surgery				
<i>n</i>	83	17	26	126
BMI (kg/m <sup>2</sup> )	41.9 (40.3-43.9)	43.4 (40.9-45.9)	41.8 (39.9-43.6)	42.0 (40.8-43.2)
BMI (%)	98.7 (98.1-99.3)	99.6 (99.4-99.8)	99.6 (99.4-99.7)	98.9 (98.6-99.4)
Weight (kg) <sup>2</sup>	132.7 (127.8-137.6)	138.5 (129.8-147.1)	128.1 (122.4-133.8)	132.4 (128.7-136.1)
EWL (kg) <sup>2</sup>	29.7 (27.4-31.9)	28.1 (22.8-33.5)	34.0 (29.6-38.4)	30.3 (28.4-32.1)
EWL (%)	18.3 (16.8-19.8)	16.2 (13.9-18.6)	20.5 (18.2-22.8)	18.4 (17.3-19.6)
12 mo after surgery <sup>2,3</sup>				
<i>n</i>	49	7	9	65
BMI (kg/m <sup>2</sup> )	39.6 (37.8-41.5)	40.2 (35.5-44.8)	37.0 (34.0-40.0)	39.3 (37.8-40.9)
BMI (%)	97.5 (95.8-99.1)	98.6 (96.9-100.4)	98.2 (96.8-99.7)	97.7 (96.5-98.9)
Weight (kg) <sup>2</sup>	125.3 (119.6-130.9)	127.9 (113.3-142.5)	113.7 (104.6-122.9)	128.7 (118.9-128.5)
EWL (kg) <sup>2</sup>	37.9 (33.7-42.1)	40.4 (26.8-54.0)	47.9 (41.2-54.6)	40.1 (36.5-43.7)
EWL (%)	22.9 (20.4-25.4)	23.0 (16.0-30.0)	29.4 (25.2-33.6)	24.0 (21.9-26.2)

Model adjusted by age and type of surgery; "Other" group not included due to small sample size; <sup>1</sup>*P* < 0.01 for change across all time points for Hispanics; <sup>2</sup>*P* < 0.001 for change across all time points; <sup>3</sup>*P* < 0.001 for change across all time points, except for weight percentile was not significant for non-Hispanic black; EWL: Estimated weight loss or the difference between baseline weight (kg) and weight at each respective time point; BMI: Body mass index.



**Table 4 Mean anthropometric values from morbidly obese girls 1 year after bariatric surgery by ethnicity**

Measurement	Non-hispanic whites, estimate (95%CI)	Non-hispanic blacks, estimate (95%CI)	Hispanics, estimate (95%CI)	Overalls, Estimate <sup>1</sup> (95%CI)
Before Surgery				
<i>n</i>	459	75	86	620
BMI (kg/m <sup>2</sup> )	46.8 (46.2-47.5)	51.6 (49.6-53.6)	47.0 (45.5-48.6)	47.5 (46.9-48.1)
BMI (%)	99.1 (99.0-99.2)	99.4 (99.3-99.5)	99.2 (99.0-99.3)	99.2 (99.1-99.3)
Weight (kg)	129.1 (127.18-131.1)	141.6 (135.4-147.7)	125.9 (121.5-130.4)	130.3 (128.6-132.1)
3 mo after surgery				
<i>n</i>	409	67	77	553
BMI (kg/m <sup>2</sup> )	43.0 (42.4-43.6)	48.0 (46.3-49.8)	43.3 (41.8-44.7)	43.7 (43.1-44.2)
BMI (%)	98.7 (98.6-98.8)	99.1 (98.9-99.2)	98.7 (98.5-98.9)	98.8 (98.7-98.9)
Weight (kg)	118.7 (116.9-120.5)	131.9 (126.3-137.6)	116.0 (111.8-120.2)	119.9 (118.2-121.6)
EWL (kg)	9.9 (9.3-10.7)	9.2 (7.6-10.7)	9.8 (8.0-11.6)	9.8 (9.2-10.4)
EWL (%)	7.7 (7.1-8.2)	6.3 (5.3-7.4)	7.7 (6.3-9.1)	7.5 (7.0-7.9)
6 mo after surgery				
<i>n</i>	297	37	52	386
BMI (kg/m <sup>2</sup> )	38.1 (37.4-38.8)	44.4 (42.3-46.4)	39.0 (37.1-40.8)	38.9 (38.3-39.6)
BMI (%)	96.5 (95.9-97.1)	98.6 (98.3-98.9)	96.9 (96.2-97.7)	96.8 (96.3-97.2)
Weight (kg)	105.3 (103.2-107.4)	121.8 (115.4-128.3)	104.2 (99.3-109.1)	107.0 (105.1-108.8)
EWL (kg)	23.7 (22.6-24.8)	20.0 (16.9-23.2)	21.2 (17.9-24.5)	22.9 (21.9-24.0)
EWL (%)	18.3 (17.5-19.1)	13.8 (11.7-15.8)	16.9 (14.4-19.5)	17.6 (16.9-18.4)
12 mo after surgery				
<i>n</i>	149	19	19	182
BMI (kg/m <sup>2</sup> )	35.6 (34.7-36.6)	40.32 (36.96-43.67)	36.65 (34.15-39.16)	36.28 (35.40-37.17)
BMI (%)	93.9 (92.6-95.1)	96.10 (92.81-99.39)	92.99 (89.48-96.51)	93.99 (92.87-95.12)
Weight (kg)	98.3 (95.5-101.0)	110.4 (100.5-120.2)	98.0 (91.3-104.6)	99.6 (97.1-102.1)
EWL (kg)	31.2 (29.1-33.4)	31.4 (24.0-38.8)	27.8 (22.9-32.6)	30.9 (28.9-32.8)
EWL (%)	23.8 (22.3-25.2)	21.1 (16.1-26.2)	22.5 (18.7-26.3)	23.4 (22.0-24.7)

Model adjusted for age and type of surgery; "Other" group not included due to small sample size; <sup>1</sup>*P* < 0.001 for change across all time points. EWL: Estimated weight loss or the difference between baseline weight (kg) and weight at each respective time point; BMI: Body mass index.

**Table 5 Mean change in anthropometric values from before to 1 year after bariatric surgery by ethnicity**

Measure	Estimated change 12 mo after surgery (mean ± SE)				<i>P</i>		
	NHW	NHB	Hispanic	Overall	NHW vs NHB	NHW vs Hispanic	NHB vs Hispanic
BMI (kg/m <sup>2</sup> )	-11.4 ± 0.5	-11.2 ± 1.6	-12.7 ± 1.2	-11.5 ± 0.4	0.87	0.29	0.41
BMI (%)	-4.7 ± 0.6	-2.7 ± 1.3	-4.9 ± 1.3	-4.6 ± 0.5	0.2	0.89	0.29
Weight (kg)	-32.2 ± 1.3	-32.3 ± 4.6	-36 ± 3.5	-32.6 ± 1.2	0.89	0.31	0.44

Model adjusted for age, sex, and type of surgery. BMI: Body mass index; NHW: Non-hispanic white; NHB: Non-hispanic black.

**Table 6 Effect of baseline body mass index on weight loss 1 year after bariatric surgery**

Variable	Baseline BMI category		
	Lowest (35-49 kg/m <sup>2</sup> )	Middle (50-59 kg/m <sup>2</sup> )	Highest (≥ 60 kg/m <sup>2</sup> )
Change in BMI, kg/m <sup>2</sup> (%) <sup>1</sup>	-9.88 (-22.6)	-14.34 (-26.5)	-17.8 (-26.7)
Rate of change over the year (kg/y)			
Non Hispanic whites <sup>2</sup>	-9.6	-14.8	-19.7
Hispanics	-11.7	-11.7	-11.6
Non Hispanic blacks	-9.3	-11.1	-15.5

<sup>1</sup>*P* < 0.0001 for lowest versus middle, lowest versus highest, and middle versus highest BMI category; <sup>2</sup>*P* < 0.0001 for lowest versus middle, lowest versus highest, and *P* = 0.002 for middle versus highest BMI category. BMI: Body mass index.

significant differences between pairwise ethnic group comparisons for all anthropometric measures (Table 5).

Changes in BMI varied somewhat by preoperative BMI category. For the entire sample, the highest BMI category lost the most BMI units when compared to lowest BMI category (17.8 kg/m<sup>2</sup> vs 9.9 kg/m<sup>2</sup>, respectively, *P* < 0.001). Only Hispanics showed no difference in weight loss between the three groups (11.7 kg/m<sup>2</sup>) (Table 6). Rate of change over the year for the three BMI categories did not vary much by ethnicity or sex, but they did by surgery type: in all three categories, BMI was reduced more among those who underwent gastric bypass surgeries than among those who had adjustable band surgeries (*P* < 0.001) (data not shown on tables).

Details about aggregate post-operative complications are published elsewhere<sup>[9]</sup>. Briefly, of the 120 complications reported (13.5%), 38 were with the gastrointestinal system and 26 were with nutritional deficiencies. Complication rates did not differ by ethnicity. Similarly, when readmissions (*n* = 55) were analyzed by ethnic group, no significant differences were found. (Data not reported).

One death was reported from cardiac arrest 5 mo after (gastric bypass) surgery.

## DISCUSSION

In a national sample of ethnically diverse, severely obese adolescents, 1 year after bariatric surgery, weight and other anthropometric measures had decreased by the same amount in all racial/ethnic groups and in both sexes. Mean estimated weight loss for all three groups at 1 year differed by a maximum of only 1.5 kg. Surgery resulted in an average weight loss of more than 30 kg per person, a loss that far exceeds those reported in non-surgical weight-management programs<sup>[21]</sup>.

Among adults, ethnicity predicts better weight loss outcomes after bariatric surgery, with some studies reporting better outcomes among NHWs than among NHBs. There is little information about outcomes in Hispanics. Harvin *et al*<sup>[13]</sup> found that 2 years after undergoing bariatric surgery, NHW adults had lost significantly more weight than did their ethnic group counterparts. Similarly, Buffington *et al*<sup>[15]</sup> found that NHB adults had less-successful weight outcomes after gastric bypass than did NHW adults. Among adults, NHB women lost considerably less weight after surgery than did NHW women<sup>[13-16]</sup>. Additionally, in the Netherlands, Admiraal *et al*<sup>[22]</sup> found that African, South Asian, Turkish and Moroccan patients lost less weight at 1-year post-gastric bypass surgery versus their ethnic Dutch counterparts.

Conversely, most studies of adolescent bariatric surgery are case series from a single-institution, resulting in samples that are generally small and relatively homogeneous, which does not permit robust comparisons among ethnic groups<sup>[8]</sup>. Although race and ethnicity are independently associated with cardiometabolic disease risk<sup>[23,24]</sup>, we found that weight loss was similar among all three ethnic groups and varied more among boys than among girls. However, no overall pairwise group comparisons were significant, indicating that no ethnic group had better weight loss outcomes than did another, unlike comparisons of adults, as described above. Parental influence over post-operative adherence to quality nutrition and physical activity recommendations may partially explain the lack of ethnic group differences.

Although the childhood obesity epidemic continues unabated in most developed countries, non-surgical approaches to the long-term (1 year or more) management and decrease of overweight in childhood have had limited success<sup>[21]</sup>. Despite standardized indications for bariatric surgery in adolescents<sup>[25]</sup>, obese children are not simply younger versions of obese adults; they are still developing and growing, both physically and psychologically. Extreme obesity should be treated sooner rather than later<sup>[8]</sup>, particularly in adolescents, who may have not yet developed full-blown, related comorbidities, such as diabetes or heart disease. Our analysis found that type of surgery significantly influences weight loss, however and thus must be a consideration for adolescents considering this

alternative; gastric bypass surgery resulted in significantly more weight loss at 1-year versus adjustable gastric band surgery. Therefore, gastric bypass may be a viable option for those who are in need of more weight loss to resolve co-morbidities that have already developed. However, the optimal age in adolescence for bariatric surgery is as yet undetermined<sup>[24]</sup>. Our findings, and those of others<sup>[26,27]</sup> indicate that bariatric surgery before adulthood can substantially reduce weight<sup>[10,25]</sup> and resolve comorbidities<sup>[25]</sup>. Moreover, earlier treatment of obesity may prevent later costs. For example, children and adolescents with a primary or secondary diagnosis of overweight, obesity, or severe obesity require longer hospital stays than do children without these diagnoses<sup>[28]</sup>.

Even as the emerging data on bariatric surgery—including those from randomized-controlled trials<sup>[26,29]</sup>—continue to show important long-term weight loss and improvement in most obesity-related comorbidities, many pediatric specialists still hesitate to refer patients for surgery<sup>[30]</sup>. A survey of several hundred pediatricians in the United States showed that, although they believed pediatric obesity to be a major problem, less than half would be somewhat or very likely to refer a severely obese adolescent for surgery<sup>[30]</sup>. Yet, the medical consequences of childhood obesity continue and suggest that overt disease beginning in early adulthood may become chronic<sup>[31]</sup>.

## Limitations of the study

Our findings and conclusions are limited by a substantial amount of missing follow-up data, a common problem in the bariatric literature among both adults and adolescents. Older adolescents in particular are difficult to follow because they may leave the geographic area for education or employment. More age-relevant tracking procedures, such as those based on social media or handheld or cellular telephone devices, may be able to decrease losses to follow-up.

Variations in practice management among BSCOPE participants may delay data entry, potentially resulting in incomplete follow-up data. Additionally, pre-surgical information on nutritional deficiencies is not available to determine whether surgery is the cause of the few deficiencies we found or whether these deficiencies existed before surgery.

Our results support the conclusion that bariatric surgery can substantially reduce weight in severely obese adolescents for at least 1 year, irrespective of their race or ethnicity. Ethnicity should not be a contraindication for bariatric surgery in adolescents, which is a reasonable and safe treatment for all severely obese adolescents with the appropriate indications.

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their data for the current analyses.

## COMMENTS

### Background

Several studies have shown that among adults, weight loss outcomes after bariatric surgery differ by ethnicity. Although the literature on outcomes of bariatric surgery in adolescents has increased exponentially, many studies are small and usually from single institutional series. As a result, patients are not geographically or ethnically diverse, despite the fact that obesity disproportionately affects ethnic minorities.

### Research frontiers

Bariatric surgery is one of the few effective treatments for morbid obesity. Among adults, outcomes of bariatric surgery differ by ethnicity.

### Innovations and breakthroughs

In a national sample of ethnically diverse, severely obese adolescents, 1 year after bariatric surgery, weight and other anthropometric measures had decreased by the same amount in all racial/ethnic groups and in both sexes. Mean estimated weight loss for all three groups at 1 year differed by a maximum of only 1.5 kg. Surgery resulted in an average weight loss of more than 30 kg per person, a loss that far exceeds those reported in non-surgical weight-management programs.

### Applications

Bariatric surgery substantially reduces the weight of severely obese adolescents at 1 year post-procedure with little variation by ethnicity and/or gender. These results suggest that bariatric surgery is a safe and reasonable treatment for all severely obese adolescents with the appropriate indications.

### Terminology

Bariatric surgery is synonymous with weight loss surgery and in this analysis consisted of two specific types: gastric bypass surgery and adjustable gastric band surgery.

### Peer review

Attrition is one of the major challenges with this patient population and that is indeed apparent in the analysis here. As a result, the authors could not simultaneously dichotomize surgery type and ethnicity thus why surgeries are reported in aggregate. Instead, the purpose of this article was to focus on exploring ethnic group differences in weight loss 1 year after surgery.

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