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Using SAS to compare effects of LAGB and RYGB, and examine other association in weight loss

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ABSTRACT

Obesity has become a major public health issue. More than one third of Americans are considered to be overweight[1]. Each year in the United States, $147 billion in health-care are related costs are attributable to obesity[2]. The main health risks of obesity are type 2 diabetes, cardio-vascular disorder, hypertension, dyslipidemia, certain types of cancer, infertility, and mortality.

Treatments for obesity can be classified into non-surgical therapy and bariatric surgery. The non-surgical therapy includes a variety of approaches such as behavioral therapy and dietary changes. The most commonly used bariatric surgery techniques are laparoscopic adjustable gastric banding (LAGB) and Roux-en-Y gastric bypass (RYGB). This project analyzed "BMI" dataset to compare weight loss with LAGB and RYGB to non-surgical therapy.

OBJECTIVE

A BMI of 30 or higher is considered obese. The "BMI" dataset includes information and measurements of 450 subjects who are randomly assigned to control group (non-surgical), LAGB group, and RYGB group. After randomization, the subjects' weights and heights were measured at baseline, 6, 12, 18, and 24 months and converted into BMIs. The number of alcoholic drinks consumed per week is collected at each visit also. The project investigated the association of weight loss with treatments, and if gender, diabetic status, hypertension status, and substance abuse (alcohol consumption) are associated with the weight loss.

METHOD

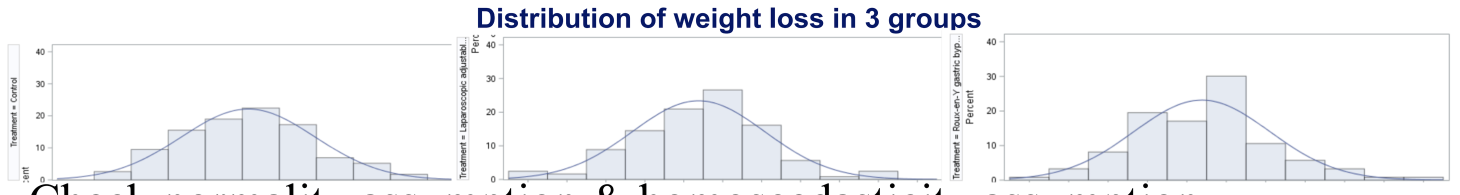
Using **ANOVA** to test the association of weight loss with treatments:

- compared the mean of BMI difference of a subject at baseline and 4th visit between the three groups

$$weight\ loss = BMI_{baseline} - BMI_{4th\ vist}$$

$$H_0:\ \mu_{control} = \mu_{LAGB} = \mu_{RYGB}\quad vs.\quad H_1: at\ least\ one\ pair\ has\ different\ means$$

Distribution of weight loss in 3 groups



Check normality assumption & homoscedasticity assumption

To investigate association between gender, diabetic status, hypertension status, and substance abuse (alcohol consumption) with BMI:

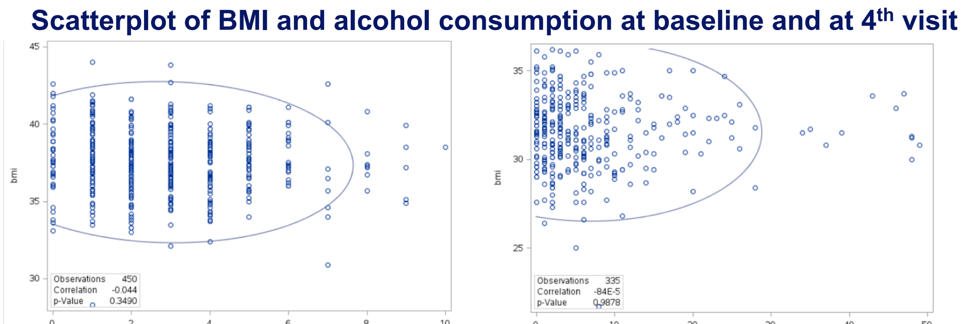
1. Using **Multiple Linear Regression** to fit a model with the last measurement (4th visit)

$$weight\ loss = \beta_0 + \beta_1 I_{gender=F} + \beta_2 I_{diabetes=Y} + \beta_3 I_{hyper=Y} + \beta_4 alcohol + \beta_5 I_{trt=LAGB} + \beta_6 I_{(trt=RYGB)}$$

2. Using **Longitudinal data analysis** to fit a model with repeated measurements and investigate the association over time

$$BMI = \beta_0 + \beta_1 I_{(gender=F)} + \beta_2 I_{diabetes=Y} + \beta_3 I_{hyper=Y} + \beta_4 alcohol + \beta_5 I_{trt=LAGB} + \beta_6 I_{(trt=RYGB)} + \beta_7 I_{visit=1} + \beta_8 I_{visit=2} + \beta_9 I_{visit=3} + \beta_{10} I_{visit=4}$$

Scatterplot of BMI and alcohol consumption at baseline and at 4th visit



RESULT

Baseline Descriptive Statistics Table

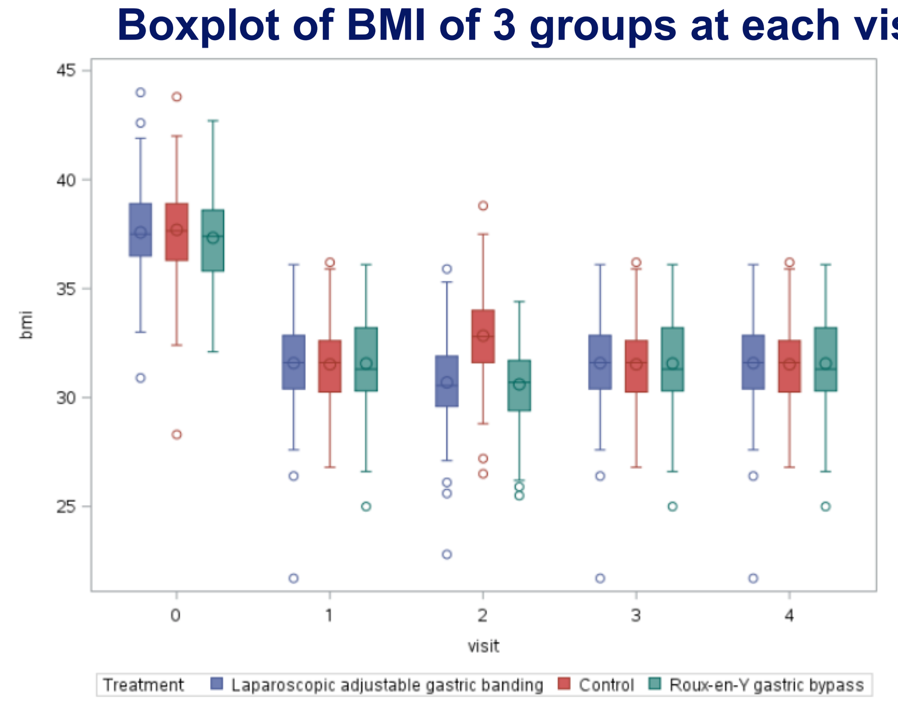
Baseline Descriptive Statistics		Control	Laparoscopic adjustable gastric banding	Roux-en-Y gastric bypass	Total
Gender					
Male	N	79	81	70	230
Female	N	71	69	80	220
Diabetic status at baseline					
No	N	37	52	47	136
Yes	N	113	98	103	314
Hypertension status at baseline					
No	N	82	94	101	277
Yes	N	68	56	49	173
BMI0	Mean	37.70	37.58	37.33	37.54
DRINK0	Mean	2.79	2.78	3.07	2.88

Missing Value Patterns of BMI and Alcohol Consumption

Group	BMI0	DRINK0	BMI1	DRINK1	BMI2	DRINK2	BMI3	DRINK3	BMI4	DRINK4	Freq	Percent
1	X	X	X	X	X	X	X	X	X	X	243	54.00
2	X	X	X	X	X	X	X	X	X	.	17	3.78
3	X	X	X	X	X	X	X	.	X	X	41	9.11
4	X	X	X	X	X	X	X	.	X	.	5	1.11
5	X	X	X	X	.	.	X	X	X	X	44	9.78
6	X	X	X	X	.	.	X	X	X	.	5	1.11
7	X	X	X	X	.	.	X	.	X	X	7	1.56
8	X	X	X	X	.	.	X	.	X	.	1	0.22
9	X	X	.	.	X	X	.	X	.	X	54	12.00
10	X	X	.	.	X	X	.	X	.	.	7	1.56
11	X	X	.	.	X	X	.	.	.	X	10	2.22
12	X	X	.	.	X	X	.	.	.	.	1	0.22
13	X	X	.	.	.	.	.	X	.	X	11	2.44
14	X	X	.	.	.	.	.	X	.	.	2	0.44
15	X	X	.	.	.	.	.	.	.	X	1	0.22
16	X	X	.	.	.	.	.	.	.	.	1	0.22

- 243 subjects (54% of total) have complete data
- The most likely measurement to be missing is BMI at visit 1, 3, 4, and alcohol at visit 1
- At visit 1 and 2, missing in BMI is always paired with missing in alcohol; while this pattern does not hold in visit 3 and 4.

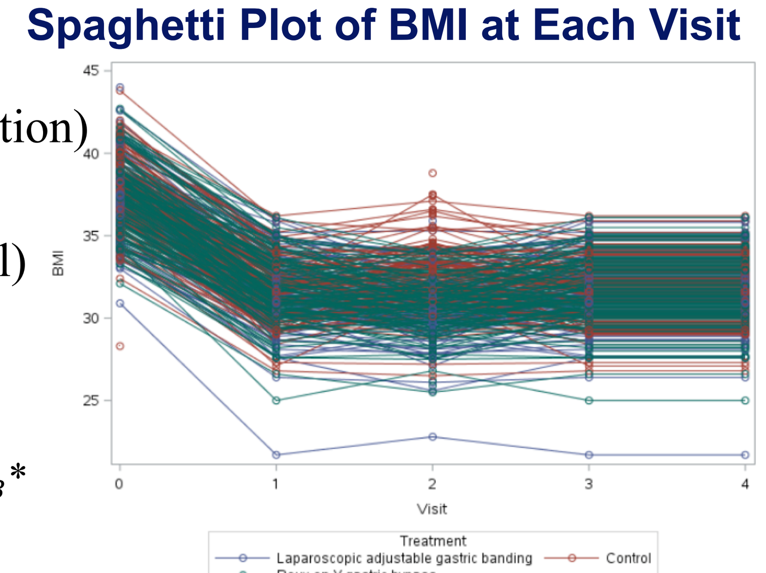
Boxplot of BMI of 3 groups at each visit



ANOVA gives an F-value of 1.01 with p-value = 0.3655 at significance level α=0.05. Therefore, we fail to reject H_0 and conclude there is no difference in BMI between control, LAGB, and RYGB group.

The boxplot of BMI of the three groups at each visit also shows that besides control group has higher BMI compared with treatment groups at visit2, BMI in three groups overlap a lot.

Spaghetti Plot of BMI at Each Visit

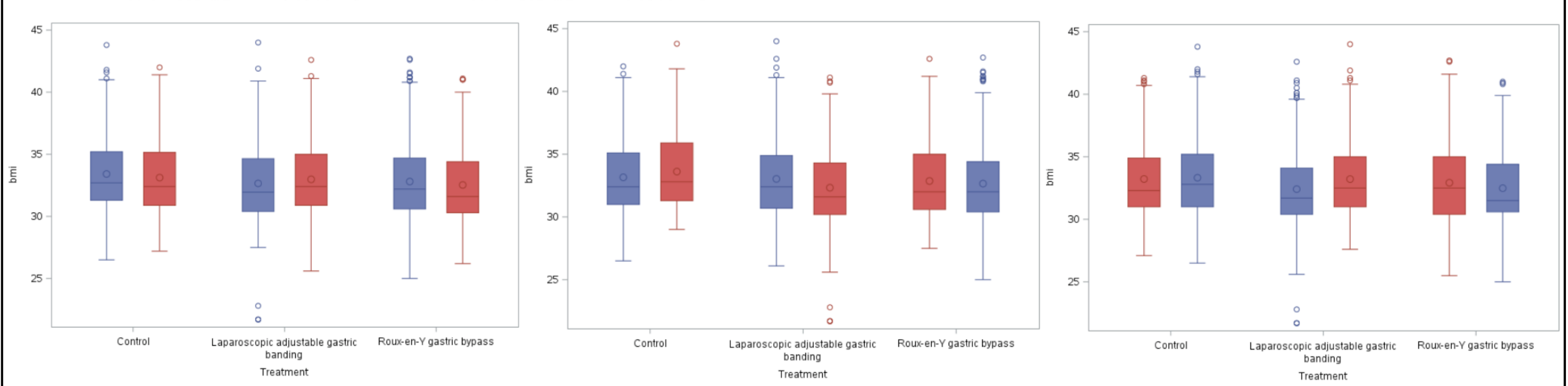


Multiple Linear Regression (using stepwise model selection)

$$weight\ loss = 6.11\ - 0.02\ alcohol_{visit4}$$

Longitudinal Data Analysis (using random effects model)

$$BMI = 37.49 + 0.01 Alcohol + 0.37 I_{gender=F} - 0.12 I_{trt=LAGB} - 0.39 I_{trt=RYGB} - 6.13 I_{visit=1} - 4.90 I_{visit=2} - 6.14 I_{visit=3} - 6.14 I_{visit=4} + 0.18\ I_{trt=LAGB} * I_{visit=1} - 2.02\ I_{trt=LAGB} * I_{visit=2} + 0.16 I_{trt=LAGB} * I_{visit=3} + 0.16 I_{trt=LAGB} * I_{visit=4} + 0.23 I_{trt=RYGB} * I_{visit=1} - 1.85\ I_{trt=RYGB} * I_{visit=2} + 0.20 I_{trt=RYGB} * I_{visit=3} + 0.16 I_{trt=RYGB} * I_{visit=4}$$



CONCLUSION

The surgery techniques laparoscopic adjustable gastric banding (LAGB) and Roux-en-Y gastric bypass (RYGB) generate similar effects as non-surgical therapy in weight loss. The difference is not statistically significant. The BMI has a decreasing trend between baseline and first visit, and tends to remain at the same level during the following visits, which possibly suggests that non-surgical therapy and the surgery therapy have a threshold in effect of reducing weight.

The model fitted using multiple linear regression with stepwise model selection shows that weight loss between the last visit and baseline is not associated with gender, diabetic status, and hypertension status, and is slightly associated with alcohol consumption measured at 4th visit. With 1 unit increase in the number of alcoholic drink consumed per week at 18 to 24 months after randomization, the expected weigh loss will decrease by 0.02kg. This model has an adjusted R-square of 0.0169, which means only 1.69% of the variation in weight loss is explained by the model, suggesting this is not a good fit. Moreover, the model uses the last measurement (i.e. 24 months after randomization) only. It does not depict the change in BMI over time.

Random effect model is used for longitudinal analysis. Adding the interaction term of treatment and visit improved the fit statistics. The model suggests that for male subjects who don't consume alcohol, the expected BMI at baseline is 37.49. For subjects assigned to LAGB group, comparing with control group at baseline, controlling for gender and number of alcoholic drinks consumed per week, at visit1 the expected BMI will decrease by 6.07, at visit2 the expected BMI will decrease by 7.04, at visit3 the expected BMI will decrease by 6.10, and at visit4 the expected BMI will decrease by 6.13; for subject assigned to RYGB group, comparing with control group at baseline, controlling for gender and number of alcoholic drinks consumed per week, at visit1 the expected BMI will decrease by 6.29, at visit2 the expected BMI will decrease by 7.14, at visit3 the expected BMI will decrease by 6.10, and at visit4 the expected BMI will decrease by 6.37. This model is selected using -2 Res Log Likelihood. Overall, the two surgery methods have similar effects in reducing weight. The best effect is reached at 12 months after randomization, and rebounded slightly in the following time.

	Visit1	Visit2	Visit3	Visit4
LAGB	-6.07	-7.04	-6.10	-6.13
RYGB	-6.29	-7.14	-6.10	-6.37

BIBLIOGRAPHY

[1] U.S. Department of Health and Human Services (2017 August) *Overweight & Obesity Statistics.* Retrieved from https://www.niddk.nih.gov/health-information/health-statistics/overweight-obesity

[2] Centers for Disease Control and Prevention (2017 March 5) *Adult Obesity Cause & Consequences.* Retrieved from https://www.cdc.gov/obesity/adult/causes.html