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An Examination of the Relationship of Problematic Food Types to the Development of Substance Use Disorder in Post-Bariatric Surgery Patients

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Secondary data analyses were conducted using de-identified data collected by Ivezaj (2011) of a sample of 154 adults who underwent bariatric surgery. Logistic regression models suggest that participants who have problems with foods high in sugar and low in fat in combination as well as foods high on the glycemic index may be at greater risk for New Onset Substance Use Disorder post-bariatric surgery. The findings also provide further evidence for the existence of differing groups among WLS patients, and for addiction transfer among WLS patients, from sugar dependence to a substance. Finally, findings of the current study may extend beyond WLS patients and provide implications for the current obesity epidemic, and the role of high sugar beverages in the development of food addiction.

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AN EXAMINATION OF THE RELATIONSHIP OF PROBLEMATIC FOOD TYPES TO THE DEVELOPMENT OF SUBSTANCE USE DISORDER IN POST-BARIATRIC SURGERY PATIENTS

By

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An Examination of the Relationship of Problematic Food Types to the Development of Substance Use Disorder in Post-Bariatric Surgery Patients

Trends in Obesity

Obesity has become a national epidemic as we continue to observe extraordinary increases in the prevalence of obesity over the last two decades (Flegal, Carroll, Ogden, & Johnson, 2002). Recently it was estimated that 68.0% of American adults are classified as overweight or obese, and 33.8% are classified as obese (Flegal, Carroll, Ogden, & Curtin, 2010). From 2000-2005, the prevalence of obesity in the US increased by 24% (Sturm, 2007). These estimates are alarming because obesity remains a risk factor for numerous negative health consequences, both medical and psychological, including diabetes, high cholesterol, hypertension, stroke, heart disease, some forms of cancer, arthritis, high mortality rates, mood disorders, binge eating, and poor quality of life (Flegal et al., 2010). Moreover, obesity remains one of the top underlying preventable causes of death in the United States (Donatelle, 2011).

Even more alarming is that rates of obesity among those at the higher end of the Body Mass Index (BMI) spectrum are increasing more rapidly than obesity in general. To explain, BMI is the most commonly used measure to classify weight status, and it is calculated using the formula: weight (lb) / [height (in)]^2 × 703 (Centers for Disease Control and Prevention). The BMI spectrum ranges from Underweight classification (below 18.5) to Obese (over 29.9) to Obese Class III (over 40 BMI). Strum (2007) reports that the heaviest BMI groups have been increasing at the fastest rates for 20 years. Specifically, from 2000-2005, the prevalence of BMI over 40 increased by 50% and the prevalence of BMI over 50 increased by 75%. Essential to the rising obesity epidemic is to understand that, while the overall prevalence of obesity is rising, the

prevalence of the most clinically severe obesity is increasing three times faster, and the most serious health concerns are associated with this morbid obesity, relative to lower BMI classifications of obesity.

Treatments for Obesity

As this trend continues, a notable increase in treatments to combat obesity has emerged including pharmacological , psychological, and surgical interventions. While current drug and behavioral treatments may often yield initial weight loss, they are ineffective at producing sustained weight loss, and often result in weight regain (North American Association for the Study of Obesity [NAASO], 2000). In essence, drug therapy is relatively unsuccessful in treating obesity, and particularly morbid obesity (BMI $\geq$ 40), in the long term, and psychosocial interventions remain inferior to surgical interventions both in terms of weight loss and eating behavior (Moldovan & David, 2011). Therefore, in 1991, the National Institutes for Health (NIH) introduced guidelines for surgical therapy for the treatment of morbid obesity, which is now referred to as bariatric surgery (NIH, 1991).

Surgical Interventions for the Treatment of Obesity

The most common Weight Loss Surgery (WLS) operations are the laparoscopic adjustable gastric banding, laparoscopic Roux-en-Y gastric bypass surgery (RYGB) and biliopancreatic diversion. The RYGB is the most popular procedure in the US (Buchwald & Oien, 2009) and produces weight loss by reducing the stomach pouch, causing the patient to consume less food, and surgically bypassing the first part of the intestine (the duodenum), resulting in the absorption of fewer calories (Nguyen et al., 2011). Initially, restriction and malabsorption were expected to be the factors producing weight loss in patients, but more recent

research suggests that the mechanisms by which weight loss occurs may be far more complex, involving surgical influences on gut hormones and leptin, creating a new "functional equilibrium" that contributes to weight loss (Michalakis & Le Roux, 2012). Moreover, recent literature reveals that reduced drug absorption in post-bariatric surgery patients appears drug-specific, suggesting again that the process is more complex than once assumed (Padwal, Brocks, & Sharma, 2010).

Although research continues to explore exactly how bariatric surgery exerts its weight loss effects, it is clear that surgical interventions have prevailed in producing the most effective weight loss for the morbidly obese, both in terms of significant excess weight loss and long term efficacy (Miras & Le Roux, 2010). Over the past decade, bariatric surgery has improved in safety and cost-effectiveness, and there has also been a marked reduction in operative mortality rates as well as mortality rates due to medical conditions associated with obesity (Nguyen et al., 2011). That is, long-term benefits of bariatric surgery are not limited to significant weight loss. Reports have documented metabolic benefits, increased life expectancy, improved quality of life, and the reversal, elimination, or improvement of diabetes, hypertension, hyperlipidemia, and obstructive sleep apnea for the majority of patients (Buchwald et al., 2004). Moreover, in a long term outcomes study by Sjöström et al. (2004), where WLS subjects were compared with a control group of conventionally treated obese subjects, the surgery group displayed significantly greater long-term weight loss, and lower rates of diabetes, hypertriglyceridemia, and hyperuricemia.

It is therefore not surprising that bariatric surgery has risen in popularity, and US adults with morbid obesity are more willing to accept surgical therapy as an option. Accordingly, an

estimated 113.6% increase in bariatric surgeries occurred from 2003 to 2008 in the US and Canada alone (Buchwald & Oien, 2009).

Poor Outcomes for Surgery Patients: A Rising Concern

While surgery remains a viable and popular answer to the problem of obesity, some bariatric surgery patients are unsuccessful in their weight loss post-surgery, and weight regain occurs for thirty percent of patients after 18 months (Hsu, Benotti, Dwyer, Roberts, Saltzman, Shikora et al., 1998). Moreover, a significant minority of patients show no psychological benefit from surgery, and concern surrounding psychological outcomes of patients has emerged (Van Hout, Boekestein, Fortuin, Pelle, & Van Heck, 2006). Specifically, new onset of major depression and substance abuse have been documented for post-surgery patients, and some have suggested that patients may undergo addiction transfer, substituting one form of addiction for another (Hsu et al., 1998; McFadden, 2010). Yet while we know little about the processes undermining successful weight loss, there remains an even more profound lack of research on substance use post- WLS.

Substance Use Disorders (SUDs) Post-Bariatric Surgery

A concern surrounding bariatric surgery is the more recent finding that post-bariatric surgery patients are overrepresented in substance abuse treatment programs (Saules et al., 2010). Results of the study indicate that the prevalence of post-bariatric surgery patients in substance abuse treatment facilities may exceed 2-6 percent, far surpassing the estimated number of bariatric surgery patients in the three year span of the study, estimated at 0.15% of the population (Nguyen et al., 2011). While Saules et al. (2010) compared patients at a substance abuse treatment program with a history of bariatric surgery to those without a history of bariatric

surgery, it follows that subsequent research must examine post-bariatric surgery patients with SUDs to those without SUDs to gain a better understanding of this phenomenon.

Accordingly, Ivezaj (2011) assessed the rates of SUD among a broad sample of post-bariatric surgery patients to determine behavioral and psychological risk factors for development of substance abuse for those patients. In particular, food addiction was of interest, primarily due to the concept of addiction transfer. To explain, the findings of the study revealed that approximately two-thirds of those with substance abuse post-surgery developed it as a new problem. That is, they had no prior history of pre-surgical substance abuse. However, contrary to expectations, it was found that pre-surgical food addiction scores were not significantly related to post-surgical substance abuse.

A follow-up study, however, did find a significant relationship between food addiction and post-surgical SUD among a broad sample of post-bariatric surgery patients (Saules, Reslan, & Schuh, 2012). Also of note is that there were still participants who met criteria for food addiction who didn't develop SUD post-surgery, necessitating further research on the relationship between food addiction and post-surgical substance abuse, as it remains unclear as to whether we are assessing food addiction in a valid manner.

Furthermore, documented evidence reveals the emergence of New-Onset Substance Users, with no prior history of pre-surgical SUD, suggesting that post-bariatric surgery patients may be a greater risk for development of New-Onset SUD. Less common, but also observed, were those who had SUD before surgery but did not relapse after surgery, and those who had SUD both pre- and post-surgery. As such, it seems that there may exist differing subsets of post-WLS patients in substance abuse treatment programs (Wiedemann, Saules, & Ivezaj, 2012).

In fact, burgeoning research suggests that physiological factors may confer risk for postoperative alcohol abuse in gastric bypass surgery patients, due primarily to putative changes in alcohol metabolism (Thanos et al., 2012; Woodard, Downey, Hernandez-Boussard, & Morton, 2011). In particular, Thanos et al. (2012) demonstrated increased ethanol and water consumption for obese rats following RYGB. Moreover, in comparing pre- and post-operative alcohol consumption for RYGB patients, it was found that patients had higher peak blood alcohol content and required more time to return to a sober level post-surgery (Woodard et al., 2011). Avena and Gold (2011) suggest that, likely still in part a result of physical and psychological factors, the increased sensitivity to alcohol post-WLS may also result from previously undiagnosed food addiction.

These findings, along with the overall dearth of research on this subject, warrant further examination of food addiction and its relevance to development of SUD post-bariatric surgery. Therefore, the present study will examine specific macronutrients, in accordance with animal models of food addiction, hypothesizing that "addiction" to some, but not necessarily all foods, may confer risk for post-WLS SUD. The following sections will give a brief overview of the research surrounding food addiction and the addictive qualities of specific macronutrients.

Food Addiction

Research on the role of addiction in obesity has led to a common model for these two conditions, predominately through both the reward model of drugs and food, and their respective implications on dopamine pathways in the brain (Volkow, Wang, Fowler, & Telang, 2008). Because brain pathways that are activated by natural rewards are also those activated by addictive substances, the concept of "food addiction" warrants empirical study (Avena, Rada, &

Hoebel, 2008). What is more, in reviewing the diagnostic criterion for dependence in relation to food, substantial evidence demonstrates that some individuals suffer from a loss of control over food consumption, failure to reduce food intake, and inability to abstain from certain foods despite negative consequences (Gearhardt, Corbin, & Brownell, 2009a), all hallmark symptoms of addiction.

Furthermore, Davis et al. (2011) recently demonstrated strong parallels between food addiction and substance abuse in a case-control design with a group of obese adults, providing evidence for food addiction as a clinically relevant phenotype of obesity. Food addition has also been established as a potential barrier to weight loss (Burnmeister, Hinman, Koball, Hoffmann, & Carels, 2012).

In a recent review of the literature surrounding food addiction and obesity, Zilberter (2012) summarizes the evidence of carbohydrate, sugar, and fat addiction, and concludes that "macronutrients play a crucial role in determining diet's behavioral and metabolic consequences." It is evident that further research on the function of each of these macronutrients in relation to both obesity and the addiction transfer phenomenon is necessary.

Animal Models of Addiction

Research with animal models has demonstrated that, under certain conditions, there is evidence for sugar dependence in rats relating to neurochemical changes in the brain, with dependence measured in four components: bingeing, indicative of tolerance, withdrawal, craving, and cross-sensitization (Avena et al., 2008). This work, in accordance with addiction and obesity literature, demonstrates that we can translate addiction research using animal models to certain human conditions, warranting further examination of the aspects of food that might

pose addictive potential for humans and the relationship of excessive consumption of these macronutrients to the emergence of SUD in post bariatric surgery patients.

The present study is drawing from the potentially addictive qualities of sugar, as it releases opioids and dopamine when ingested (Avena et al., 2008), two neurochemicals whose release are also produced by most misused drugs, and implicated in the euphoric mood associated with many addictive substances, including opiates and psychostimulants (Franken, 2007). Further, it has been demonstrated that high sugar intake in the absence of a high fat diet may be the most likely to yield addictive features (Avena, Bocarsly, & Hoebel, 2012).

Glycemic Index

Another candidate for addictive qualities is the glycemic index (GI). The GI is a classification proposed to quantify the blood glucose response following the consumption of foods containing carbohydrate (Jenkins et al., 1981). The GI classification of carbohydrates becomes relevant when we understand that the insulin response following consumption of carbohydrate foods is influenced by the level of the glucose response, with notable individual variation (Holt, Brand Miller, & Petocz, 1997). It has been demonstrated that elevations in insulin levels associated with specific food types produce increased hunger and food intake, as well as heightened levels of perceived sweetness. Insulin also influences fatty-acid synthesis, and insulin resistance (Rodin, 1985). For the present study, the documented amplification of glucose and insulin responses following repeated consumption of high GI foods warrants further examination of the putative addictive qualities of high GI carbohydrates.

Hypotheses

1. It is hypothesized that those participants who find foods with high sugar and low fat as primarily problematic will be those most likely to display addiction transfer post-surgery. Stated differently, participants who report a greater number of problematic foods that are high sugar and low fat in combination will be more likely to develop SUD post-surgery, and specifically at greater risk for being a "new-onset user," to be explained below.
2. It is also expected that those participants who selected a greater number of foods that are high on the glycemic index will be at greater risk of developing SUD post-WLS.
3. It is also hypothesized that those participants with a higher number of problematic foods in general will be more likely to develop SUD post-surgery.

Method

Participants

The present study will gain IRB approval to use de-identified secondary data from that collected by Ivezaj (2011) of Eastern Michigan University. The previous study recruited a broad sample of 154 adults, aged 18 and older, with a history of bariatric surgery. Of this sample, 59.7% were recruited from an online bariatric surgery support group, and 40.3% were recruited from St. Vincent Hospital's bariatric treatment program. The sample was predominantly White (94.2%) and female (88.4%), with a mean age of 48.66 (SD ± 10.82) and BMI of 32.34 (SD ± 6.65). The majority of patients underwent RYGB (92.9%) and the mean number of years for participants since surgery was 2.70 (SD ± 2.23).

Using the MAST-AD cutoff score of 5 or greater, 18.8% of participants met criteria for substance abuse post-surgery, and 21.4% of the sample met criteria for substance abuse at some point prior to surgery. Furthermore, relevant to the present study, four groups were created among the population of participants, No Problematic Use (66.2% of participants), Recovered

(14.9%), Relapsed (6.5%), and New-Onset Abuse (12.3%). How MAST-AD scores were used to create these four groups is defined below, under statistical analyses.

Measures

The Michigan Assessment Screening Test for Alcohol and Drugs (MAST-AD) is a modified version of the commonly used self-report questionnaire known as the Michigan Alcoholism Screening Test (MAST). The MAST-AD incorporates drug use as well, and has been identified as a measure of severity rather than as a screening tool. It consists of 24 "yes" or "no" questions, and scores of eight or more are indicative of chronic substance abuse, while scores of 5 or more indicate probable SUD. Refer to Appendix A.

The Yale Food Addiction Scale (YFAS) is the current standard in assessing potential for addiction to food. It measures behavioral addictions and dependence via a survey based upon substance dependence criteria in the DSM-IV-TR (Gearhardt, Corbin, & Brownell, 2009b). The present study will utilize the "Problematic Foods" list included in the YFAS to measure the relationship between problematic food types to the development of SUDs in post bariatric surgery patients. Refer to Appendix B.

Procedure

The sample of participants for which the data for the present study will come from was recruited through two methods. A URL link to the survey was posted on an online support group, moderated by a bariatric patient from Henry Ford Hospital (Detroit, MI), and all participants received a $25 gift card for their participation after completing the survey. Participants were also recruited through St. Vincent Bariatric Center of Excellence (Carmel, IN), from either a long term outcomes study or during follow-up visits at the Bariatric Center.

The YFAS assessed pre-surgical food addiction using retrospective recall; that is, participants were asked to complete the measure about their eating behavior before they underwent bariatric surgery. While retrospective data often has limitations, it is reasonable to assume that, given the dramatic changes in eating behavior that occurs for patients after bariatric surgery, recall of problematic eating behavior may be more reliable.

All participation in the study was voluntary; data were kept confidential; and prior to data collection, the study was approved by the Eastern Michigan University Human Subjects Review Committee. The current study will also gain IRB approval for secondary data analysis.

Analytic Plan

A classification table was developed to classify the 28 problematic foods listed at the end of the YFAS based on their nutrient content into categories to aid in analysis. The nutrient content for energy, grams of fat, grams of sugar, milligrams of sodium, and grams of carbohydrate were retrieved from the United States Department of Agriculture (USDA) National Nutrient Database (2012) based on standard serving sizes outlined by Western Michigan University (n.d.). Serving sizes listed by the manufacturer were used in the absence of an outline by Western Michigan University. All grams of fats, sugars, and carbohydrates were converted to calories and the proportion of calories from each specific macronutrient to the overall calories in the serving were determined and converted to a percentage. The percentage of total calories from sugar only included added sugars, and the percentage of total calories from carbohydrates did not include these added sugars.

Standards devised by the USDA and the National Academy of Science were used to classify foods as "High Fat" or "High Sugar." Specifically, a food was classified as "High Fat"

if it contained more than 35% of its total calories from fat, and as "High Sugar" if it contained more than 25% of its total calories from added sugars (National Academy of Science, 2005; USDA, 2004). If a food contained at least 5% (120 mg) per serving of the 2400 mg daily recommended value for sodium for adults, it was determined to be "High Sodium," as the assumption is that more than one serving would be consumed given that these are self-reported problem foods. Lastly, using white bread as a prototype for a food high in carbohydrates, a food serving that contained more than 55% of its total calories from added, nonsugar carbohydrates was classified as "High Carb."

Several foods, specifically pizza and hamburgers, that did not meet the criteria to be classified as "high fat" but were within several percentages, were determined to be high fat foods for our research purposes due to the fact that participants were primed to conceptualize these foods as "fatty" at the beginning the YFAS.

The GI for each food was determined from the Sydney University GI Research Service (2011). Accordingly, universal guidelines for the GI were followed such that a food was classified as low on the GI scale if it's GI was <55, medium if it was between 56-69, and high if it was >70. Refer to Appendix C for the classification of foods.

Drawing from the previous study by Ivezaj (2011), substance abuse was determined by comparing those who scored 5 or above with those who scored 4 or less on the MAST-AD, given the small sample size, and shortened length of time to develop a chronic condition.

Data analyses will be conducted using SPSS version 20. For hypothesis 1, the reported number of problematic foods high in sugar and low in fat will be compared with development of SUD post-surgery by utilizing binomial logistic regression. It will also be prudent to examine

the relationship between the number of reported high sugar foods overall with development of SUD post-WLS. The problematic food variables will be treated as proportional to the number of macronutrient-specific foods available to select. For example, if a subject reported problems with two foods classified as high sugar, and there are seven high sugar foods available to select on the YFAS, the variable measurement is 2/7.

For hypothesis 2, binary logistic regression will be utilized to determine if the glycemic index may be a potential predictor variable for SUD post-WLS, where the variable is measured by the number of selected foods high on the GI out of the total number of problem foods selected by the participant. For hypothesis 3, a t-test will be employed to assess whether those who report a greater number of problematic foods overall will be at increased risk of developing SUD post-surgery.

In addition, analyses will be conducted using both a two-group comparison, comparing those who met criteria for substance abuse post-surgery and those who didn't, as well as using a four-group comparison, which will take into account a participant's pre-surgical history of substance use. The four groups will be examined separately to further assess addiction transfer and will be classified based on MAST-AD scores listed in Table 1.

Table 1

No Problematic Use	Recovered	Relapsed	New-Onset Abuse
< 5 pre- and post-surgery	≥ 5 pre-surgery and < 5 post-surgery	> 5 pre- and post-surgery	< 5 pre- and ≥ 5 post-surgery

Note that MAST-AD scores ≥ 5 are indicative of problematic substance abuse as outlined in the methods section.

Lastly, because researchers still lack a clear understanding of those specific macronutrients that may be the most addictive, we will examine a bivariate correlation matrix with all of the macronutrient variables presented against the development of SUD. Predictor variables that are statistically significant will be considered candidates for logistic regression to determine the best predictor model.

Results

Participant demographic variables are summarized in Table 2. Note that the majority of participants were female (88.4%), White (94.2%), and underwent gastric bypass surgery (92.9%). The rate of substance abuse was assessed across the four groups previously mentioned. The percentage of the sample that fell within each group, using the MAST-AD scores presented in Table 1, is listed in Table 3.

Table 2

Demographic Variables	Participants (n = 154)
Gender (% female)	88.4%
Race (% White)	94.2%
Age	48.66 ± 10.82
Bariatric Surgery type (% Roux-en-Y)	92.9%
Years since surgery	2.70 ± 2.23
Education (yrs)	15.01 ± 2.82
Marital status (% married)	64.9%
Employment status	
Employed at least part time	67.4%
Economic status	
Solidly middle class and below	84.5%

Table 3

	No Problematic Use	Recovered	Relapsed	New-Onset Abuse
N	102	23	10	19
%	66.2%	14.9%	6.5%	12.3%

Refer to Table 1 for MAST-AD scoring criteria for the creation of the groups.

Exploratory, descriptive statistics were examined for the four groups above comparing all predictor variables, namely, the percentage of macronutrient specific foods a participant endorsed on the YFAS out of the total macronutrient specific foods presented in the problematic foods section of the survey. The statistically significant differences among groups from a post-hoc comparison of means using Tukey's Honest Significant Difference (HSD) test are presented in Table 4. ANOVA results confirmed hypotheses 1 and 2. That is, New Onset Users differed from Non-Users in that they endorsed more problematic foods high on the Glycemic Index ($F=4.880$, df –3, $p=.003$, $\eta^2 = 0.089$) as well as foods that were High Sugar and Low Fat in combination ($F=3.257$, df–3, $p=.023$, $\eta^2 – 0.061$). Recovered Users differed from Non-Users in their increased endorsement of problematic foods high in sodium ($F=4.765$, df=3, $p=.003$, $\eta^2 = 0.087$) and high in fat ($F=3.810$, df=3, $p=.011$, $\eta^2 = 0.071$). There were no other significant and meaningful differences among groups for any other predictor variables, although variables created in combination with High GI foods were significant, yet highly correlated with each other. Notably, endorsement of High Sugar foods alone did not differ significantly among groups ($F=1.853$, df=3, $p=.140$). Refer to figures 1-5 for the breakdown of the means for each group.

Table 4

Variable	Group Comparison	Mean Difference	S.E.	*p*	95% C.I.
Glycemic Index	New Onset Use vs. No Problematic Use	19.7258*	6.2678	.011	3.4416 – 36.010
High Sugar & Low Fat	New Onset Use vs. No Problematic Use	25.3354*	9.1050	.031	1.6800 – 48.9908
High Fat	No Problematic Use vs. Recovered	16.0732*	5.3520	.016	2.1684 – 29.9780
High Sodium	No Problematic Use vs. Recovered	15.4732*	5.4402	.026	1.3392 – 29.6070

*Differences are significant at the .05 level.

Figure 1

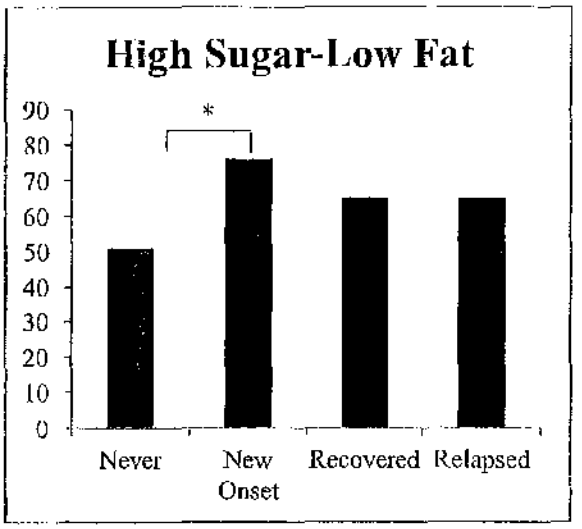


Figure 2

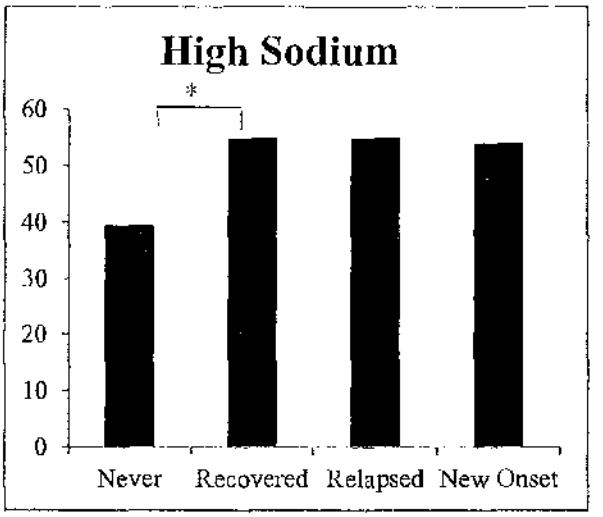


Figure 3

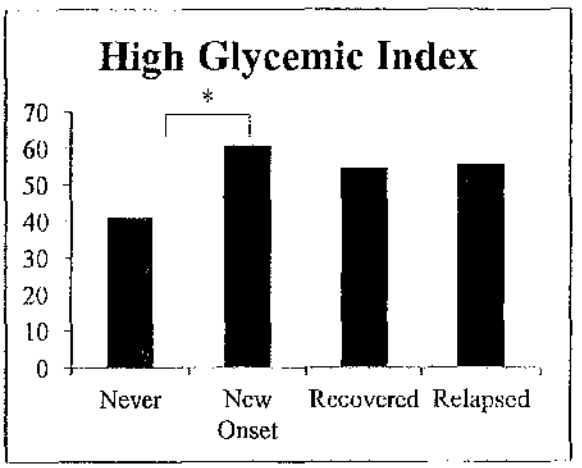


Figure 4

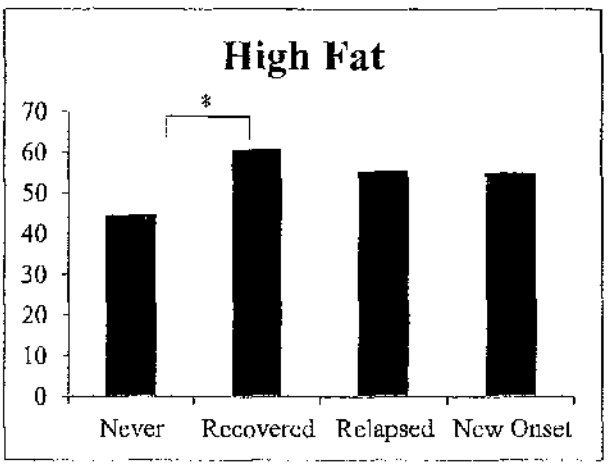
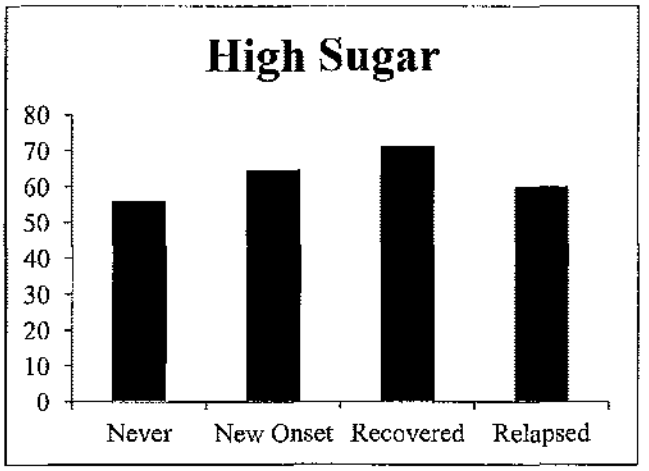


Figure 5



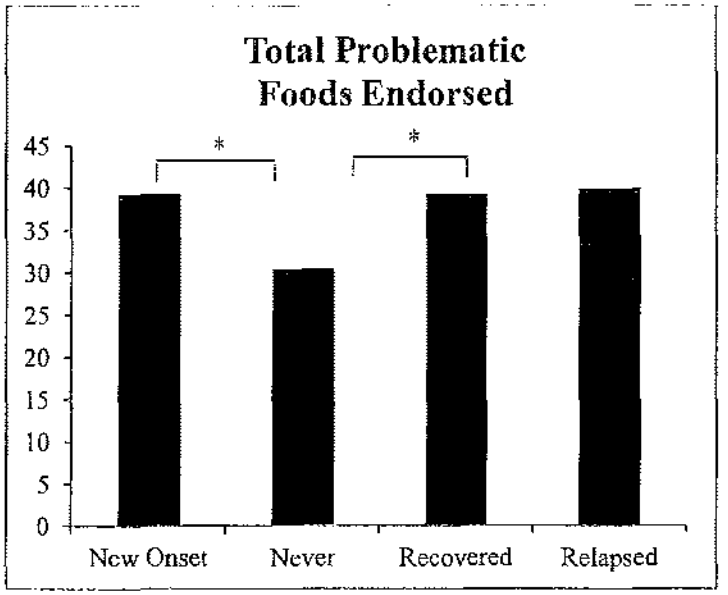
*Differences in means are significant at the .05 level. Means between groups did not significantly differ for endorsement of high sugar foods.

To test hypothesis 3, means for all four groups were compared to analyze differences among groups that endorse total problematic foods. Significant differences were found between New Onset Users and Non-Users, as well as Recovered Users and Non-Users ($F=3.812$, $df=3$, $p=.011$, $\eta^2 = 0.071$). Table 5 displays the significant differences in means from Fisher's Least Significant Difference (LSD) test. Figure 6 depicts the breakdown of means.

Table 5

Group Comparison	Mean Difference	S.E.	p	95% C.I.
New Onset Use vs. No Problematic Use	9.5404*	3.9350	.017	1.7652 – 17.3156
Recovered vs. No Problematic Use	8.7885*	3.6351	.017	1.6059 – 15.9712

Figure 6



*Differences in means are significant at the .05 level.

Lastly, all predictors that were significant in the original analyses were entered into a logistic regression model, namely the percent of High Sugar and Low Fat foods endorsed, the percent of High GI foods endorsed, the percent of High Sodium foods endorsed, and the percent of High Fat foods endorsed. After controlling for potential predictor variables for New-Onset Users, such as family history of substance abuse, and pre-surgical BMI (Ivezaj, 2011), analyses revealed that participants were at statistically significant greater risk for development of New Onset SUD if they endorsed a larger percentage of problematic foods high on the GI (OR=1.027, p=.019) or High Sugar and Low Fat foods (OR=1.018, p=.032). Refer to Table 6 and 7.

Table 6

Model for No Problematic Use vs. New Onset Use

	B	S.E.	Wald	Odds Ratio	95% CI	p
Family History	1.482	.576	6.616	4.402	1.423-13.619	.010
Pre-surgical BMI	.051	.027	3.532	1.052	.998-1.110	.060
% of GI foods endorsed	.027	.011	5.464	1.027	1.004-1.051	.019

Table 7

Model for No Problematic Use vs. New Onset Use

	B	S.E.	Wald	Odds Ratio	95% CI	*p*
Family History	1.543	.572	7.263	4.677	1.523-14.360	.007
Pre-surgical BMI	.053	.027	3.849	1.055	1.000-1.113	.050
% of High Sugar/Low Fat foods endorsed	.018	.008	4.584	1.018	1.002-1.035	.032

Moreover, logistic regression models revealed that participants were at statistically significant greater risk to be in the Recovered group if they endorsed a greater percentage of High Fat foods (OR=1.025, p=.021) and High Sodium foods (OR=1.022, p=.036), even after controlling for family history of substance abuse. Notably, after controlling for Emotional Eating Scale scores, another significant predictor variable, High Fat and High Sodium variables were no longer significant. Emotional eating and consuming highly palatable foods, like those high in fat and salt, may be highly correlated. Refer to Tables 8-11.

Table 8

Model for No Problematic Use vs. Recovered Group

	B	S.E.	Wald	Odds Ratio	95% CI	*p*
Family History	1.492	.517	8.338	4.445	1.615-12.237	.004
% of High Fat foods endorsed	.025	.011	5.362	1.025	1.004-1.047	.021

Table 9

Model for No Problematic Use vs. Recovered Group

	B	S.E.	Wald	Odds Ratio	95% CI	*p*
Family History	1.478	.516	8.221	4.386	1.597-12.049	.004
% of High Sodium foods endorsed	.022	.010	4.410	1.022	1.001-1.043	.036

Table 10

Model for No Problematic Use vs. Recovered Group

	B	S.E.	Wald	Odds Ratio	95% CI	*P*
Family History	1.391	.524	7.040	4.021	1.439-11.238	.008
Emotional Eating Scale Total	.018	.013	2.114	1.018	.994-1.044	.146
% of High Fat foods endorsed	.017	.012	1.962	1.017	.993-1.042	.161

Table11

Model for No Problematic Use vs. Recovered Group

	B	S.E.	Wald	Odds Ratio	95% CI	*P*
Family History	1.377	.525	6.883	3.962	1.416-11.081	.009
Emotional Eating Scale Total	.020	.012	2.806	1.020	.997-1.045	.094
% of High Sodium foods endorsed	.014	.011	1.565	1.014	.992-1.037	.211

Discussion

The present study examined the relationship of self-reported problematic food types to the development of substance abuse among post-bariatric surgery patients. The study also sought to investigate the putative addictive qualities of macronutrients and assess addiction transfer among the post-bariatric surgery population. Furthermore, the study attempted to identify risk factors for New Onset SUD among a post-bariatric surgery population, drawing from documented relationships between food addiction and substance abuse, and literature examining sugar dependence and new onset substance abuse post-RYGB in animal models.

A conservative post-hoc test, Tukey's HSD test, was employed to compare the differences in means between the four groups. In accordance with hypothesis 1, New Onset Users who had greater problems with foods high in sugar and low in fat in combination before surgery were at greater risk of developing problematic substance use post-surgery when compared to those without any problematic substance use, while controlling for family history of

substance abuse, an inherent risk factor for substance abuse (Dawson, Harford, & Grant, 1992), and pre-surgical BMI. Logistic regression analyses also confirmed hypothesis 2 in that New Onset Users who reported having more problem foods high on the GI were at greater risk of developing SUD post-bariatric surgery than were No Problematic Use participants, even after controlling for family history of substance abuse and pre-surgical BMI. Lastly, in accordance with hypothesis 3, New Onset Users endorsed a greater percentage of problematic foods in total, when compared with participants with no problematic use. A liberal post-hoc test, Fisher's LSD, was employed, given that this particular analysis was more exploratory and supported by anecdotal evidence above empirical study.

Consistent with the literature on animal models of addiction, findings provide further evidence for the potential addictive qualities of high sugar foods in the absence of high fat (Avena, Rada, & Hoebel, 2008; Avena, Borcarsly & Hoebel, 2012), particularly in the context of 'addiction transfer.' Lending greater significance to these findings, endorsement of foods that were High Sugar alone did not differ among post-operative groups. Increased sensitivity to alcohol and changes in alcohol metabolism for post-surgery patients (Thanos et al., 2012; Woodard et al., 2011) again support findings of post-operative substance abuse, yet the emergence of New Onset substance use disorder among patients, and the significantly greater endorsement of problem foods with potential addictive qualities suggest that New Onset abuse may result from previously undiagnosed food addiction (Avena & Gold, 2011). The present study demonstrates this relationship if we consider that the role of macronutrients in the diagnosis of "food addiction" be given greater attention.

Interestingly, Recovered Users, participants who had problematic substance use prior to surgery and no problematic use post-surgery, also endorsed a significantly greater total

percentage of problematic foods compared to participants with no problematic use. In contrast to the High Sugar/Low Fat and High GI distinctions that were important in characterizing the New Onset group, Recovered Users differed from No Problematic Use participants in their mean endorsement of foods high in sodium and high in fat. Logistic regression models confirmed that participants who endorsed a greater percentage of foods that were high in fat or high in sodium were more likely to have had a substance use problem prior to surgery, but no problematic use after surgery. In addition, they had greater likelihood of being part of the Recovered Group, even after controlling for family history of substance abuse.

While research on the development of substance abuse is extensive, the literature is quite silent on the subject of recovery, and why some individuals may remain resistant to relapse, especially after experiencing a major life adjustment, such as undergoing bariatric surgery. Foods that are high in fat and sodium are often deemed highly palatable, and these emerging relationships among Recovered Users warrant further study. Much of the research on resiliency concerns at-risk youth, and protective social and personality factors (Bernard, 1991; Dugan, 1997; Wells, 2007), and future research could benefit from considering the role of macronutrients as a potential protective factor from relapse.

The current research further supports the emergence of differing groups among WLS patients, and suggests that these groups develop through differing mechanisms. Notably, almost two-thirds of the current sample that developed problematic substance use after surgery developed it as a new problem, forming this New Onset group of participants. The current literature supports the claim that differing groups exist among WLS patients (Ivezaj, 2011; Wiedemann et al., 2012; Hsu et al., 1998) and changes in alcohol metabolism (Thanos et al., 2012; Woodard et al., 2011) and reduced drug absorption (Padwal et al., 2010) following

bariatric surgery suggest that we might expect postoperative substance abuse to occur for some patients. Current findings demonstrate that macronutrients may lend an important role in differentiating these groups among surgery patients, and that the mechanisms by which the WLS groups differ are clearly complicated, and warrant further study, particularly to assess risk factors for New Onset Users.

The present study had a few limitations. Given that the study used secondary data, future research should develop and validate a more systematic method of assessment of "problem foods," ideally one that avoids the inherent limitations of retrospective recall, where eating behavior before surgery would be observed on a closed unit. What is more, after using the algorithm developed to classify the 28 problematic foods on the YFAS based on their macronutrient content, only two foods were classified as High Sugar/Low Fat, namely "candy" and "soda pop." It is likely that what most participants were endorsing were high sugar beverages. The overwhelming prevalence and overconsumption of high sugar beverages in today's society, a current controversial topic in public policy, along with the results of the present study, lend justification for further research on the impact of high sugar beverage intake on the development of "food addiction." Secondly, while the sample was large (n=154), after the four groups were created, three of the groups, namely the Recovered, Relapsed, and New Onset Use groups, had small sample sizes. The research should be replicated with a larger sample size. Nonetheless, the fact that significant effects emerged with a presumably underpowered study suggests that the effects that were observed may be quite large in magnitude, and helps explain some effect in an area where research is scant. Furthermore, a longitudinal study would be best to assess substance abuse after surgery, given the shortened length of time participants had to

develop a substance use problem and that some participants may have developed problematic use after the study concluded.

Despite these limitations, the fact that significant findings emerged at all among this preliminary study is quite remarkable and lends support for future research in this area. What is more, the findings still provide evidence for addiction transfer among post-bariatric surgery patients, as well as the emergence of differing groups among the bariatric surgery population. Moreover, the study lends intriguing support for putative food addiction and sugar dependence, specifically, the addictive quality of foods high in sugar in the absence of high fat. Future research should explore the influence of amplified insulin responses that occur upon repeated consumption of foods classified as high on the Glycemic Index, and their potential addictive quality. The findings of the current study could extend beyond the post-bariatric surgery population, and provide intriguing implications for the current obesity epidemic, and the role of high sugar beverage consumption as well as food addiction in this crisis.

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Appendix A

MAST-AD

Note that directions and items were reworded to either reflect "BEFORE you had bariatric surgery," or "currently," for the pre-bariatric and post-bariatric assessment, respectively.

	Score	
	Yes	No
0. Do you enjoy a drink or drug use now and then?	0	0
1. Do you feel you are a normal drinker or drug user? (By normal we mean you drink or use drugs less than or as much as most other people.)	0	2
2. Have you ever awakened the morning after some drinking or drug use and found that you could not remember a part of the evening?	2	0
*3. Does your wife, husband, a parent, or other near relative ever worry or complain about your drinking or drug use?	1	0
4. Can you stop drinking or using drugs without a struggle after one or two drinks or drug doses?	0	2
5. Do you feel guilt about your drinking or drug use?	1	0
6. Do friends or relatives think you are a normal drinker or drug user?	0	2
7. Are you able to stop drinking or drug use when you want to?	0	2
8. Have your ever attended a meeting of Alcoholics Anonymous,		

Narcotics Anonymous or other self-help group for drug use?	5	0
9. Have you gotten into physical fights when drinking or drug use?	1	0
10. Has your drinking or drug use ever created problems between you and your wife, husband, a parent, or other relatives?	2	0
11. Has you wife, husband (or other family members) ever gone to anyone for help about your drinking or drug use?	2	0
12. Have you ever lost friends because of your drinking or drug use?	2	0
13. Have you ever gotten into trouble at work because of your drinkingor drug use?	2	0
14. Have you ever lost a job because of drinking or drug use?	2	0
15. Have you ever neglected your obligations, your family, or your work for two or more days in a row because you were drinking or using drugs?	2	0
16. Do you drink or use drugs before noon fairly often?	1	0
17. Have you ever been told you have liver trouble? Cirrhosis?	2	0
18. After heavy drinking or drug use have you ever had Delirium Tremens (D.T.'s) or severe shaking, or heard voices or seen things that really weren't there? How many times? _	2	0
19. Have you ever gone to anyone for help about your drinking or drug use?	5	0

20. Have you ever been in a hospital because of drinking or drug use?	5	0
21. Have you ever been a patient in a psychiatric hospital or on a psychiatric ward of a general hospital where drinking or drug use was apart of the problem that resulted in hospitalization?	2	0
22. Have you ever been seen at a psychiatric or mental health clinic or gone to any doctor, social worker, or clergyman for help because of any emotional problem, where drinking or drug use was part of the problem?	2	0
23. Have you ever been arrested for drunk driving, driving while intoxicated, or driving under the influence of alcoholic beverages or drugs? How many times?	2	0
24. Have you ever been arrested, or taken into custody, even for a few hours, because of other drunk or drug-related behavior? How many times?	2	0

*Note that this is the measurement that was given to research participants with question 3 corrected, and is not as published by Westermeyer, Yargic, & Thuras (2004).

Appendix B

Yale Food Addiction Scale

This survey asks about your eating habits before you had bariatric surgery. People sometimes have difficulty controlling their intake of certain foods such as:

- Sweets like ice cream, chocolate, doughnuts, cookies, cake, candy, ice cream
- Starches like white bread, rolls, pasta, and rice
- Salty snacks like chips, pretzels, and crackers
- Fatty foods like steak, bacon, hamburgers, cheeseburgers, pizza, and French fries
- Sugary drinks like soda pop

When the following questions ask about "CERTAIN FOODS" please think of ANY food similar to those listed in the food group or ANY OTHER foods you have had a problem with in the past year

BEFORE YOU HAD BARIATRIC SURGERY:	Never	Once a month	2-4 times a month	2-3 times a week	4 or more times or daily
I found that when I started eating certain foods, I ended up eating much more than planned	0	1	2	3	4
I found myself continuing to consume certain foods even though I was no longer hungry	0	1	2	3	4
I ate to the point where I felt physically ill	0	1	2	3	4

Not eating certain types of food or cutting down on certain types of food was something I worried about	0	1	2	3	4
I spent a lot of time feeling sluggish or fatigued from overeating	0	1	2	3	4
I found myself constantly eating certain foods throughout the day	0	1	2	3	4
I found that when certain foods were not available, I would go out of my way to obtain them. For example, I would drive to the store to purchase certain foods even though I had other options available to me at home.	0	1	2	3	4
There were times when I consumed certain foods so often or in such large quantities that I started to eat food instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoyed.	0	1	2	3	4
There were times when I consumed certain foods so often or in such large quantities that I spent time dealing with negative feelings from overeating instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoyed.	0	1	2	3	4
There were times when I avoided professional or social situations where certain foods were available, because I was afraid I would overeat.	0	1	2	3	4
There were times when I avoided professional or social situations because I was not able to consume certain foods there.	0	1	2	3	4
I had withdrawal symptoms such as agitation, anxiety, or other physical symptoms when I cut down or stopped eating certain foods. (Please do NOT include withdrawal symptoms caused by cutting down on caffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)	0	1	2	3	4
I consumed certain foods to prevent feelings of anxiety, agitation, or other physical symptoms that were developing. (Please do NOT include consumption of caffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)	0	1	2	3	4

BEFORE YOU HAD BARIATRIC SURGERY:	NO	YES
My food consumption caused significant psychological problems such as depression, anxiety, self-loathing, or guilt.	0	1
My food consumption caused significant physical problems or made a physical problem worse.	0	1
I kept consuming the same types of food or the same amount of food even though I was having emotional and/or physical problems.	0	1
Over time, I have found that I needed to eat more and more to get the feeling I wanted, such as reduced negative emotions or increased pleasure.	0	1
I found that eating the same amount of food did not reduce my negative emotions or increase pleasurable feelings the way it used to.	0	1
I wanted to cut down or stop eating certain kinds of food.	0	1
I tried to cut down or stop eating certain kinds of food.	0	1
I was successful at cutting down or not eating these kinds of food.	0	1

How many times in one year would you try to cut down or stop eating certain foods altogether?	1 time	2 times	3 times	4 times	5 or more times

Please circle ALL of the following foods you had problems with:

Ice cream	Chocolate	Apples	Doughnut	Broccoli	Cookies	Cake	Candy
White Bread	Rolls	Lettuce	Pasta	Strawberries	Rice	Crackers	Chips
Pretzels	French Fries	Carrots	Steak	Bananas	Bacon	Hamburgers	Cheese burgers
Pizza	Soda Pop	None of the above					

Please list any other foods that you had problems with that were not previously listed:

Appendix C

Foods	High Sugar	High Fat	High Carb	High Sodium	Glycemic Index
Ice Cream	Y	Y	N	N	Low
Chocolate	Y	Y	N	N	Low
Apples	N	N	N	N	Low
Doughnuts	Y	Y	N	Y	High
Broccoli	N	N	N	N	n/a
Cookies	Y	Y	N	Y	Medium
Cake	Y	Y	N	Y	Low
Candy	Y	N	N	N	High
White Bread	N	N	Y	Y	High
Rolls	N	N	Y	Y	High
Lettuce	N	N	N	N	n/a
Pasta	N	N	Y	N	Low
Strawberries	N	N	N	N	Low
Rice	N	N	Y	N	Medium
Crackers	N	Y	N	Y	High
Chips	N	Y	N	Y	Medium
Pretzels	N	N	Y	Y	High
French Fries	N	Y	N	Y	High
Carrots	N	N	N	N	Low
Steak	N	Y	N	Y	n/a

Foods	High Sugar	High Fat	High Carb	High Sodium	Glycemic Index
Bananas	N	N	N	N	Low
Bacon	N	Y	N	Y	n/a
Hamburgers	N	Y*	N	Y	Medium
Cheeseburgers	N	Y	N	Y	Medium
Pizza	N	Y*	N	Y	Medium
Soda Pop	Y	N	N	N	Medium

*Note that exceptions were made to classify hamburgers and pizza as high fat, as outlined in the measures.