PSYCHOPATHOLOGY AND FIVE-YEAR ROUX-EN-Y GASTRIC BYPASS OUTCOMES IN BARIATRIC SURGERY PATIENTS

A dissertation submitted
to Kent State University in partial
fulfillment of the requirements for the
degree of Doctor of Philosophy

by
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CHAPTER I

INTRODUCTION

Obesity is a worldwide public health crisis. The World Health Organization (WHO, 2013) estimated that 1.4 billion adult individuals were overweight in 2008. Of those, nearly 600 million men and women were considered obese – defined as having a Body Mass Index (BMI) of 30 kg/m$^2$ or more. In the U.S., approximately 6% of the population have a BMI $\geq 40$kg/m$^2$ (Flegal, Carroll, Ogden, & Curtin, 2010). Obesity is a concern owing to its association with many physical health problems, including Type 2 diabetes, cardiovascular risk factors, cancer, and sleep apnea (Calle, Rodriguez, Walker-Thurmond, & Thun, 2003; Mechanick et al., 2013; Strobel, 1996; von Eyben et al., 2003). In addition to medical comorbidity, obesity is also associated with early mortality (WHO, 2013). Importantly, it is also preventable and treatable.

For a subset of obese individuals, specifically those with a BMI $\geq 40$kg/m$^2$ or $\geq 35$ kg/m$^2$ with a comorbid medical condition, bariatric surgery can be a viable option for weight loss and resolution of comorbid conditions. This procedure is an effective treatment for obesity, with better weight loss outcomes than diet, lifestyle changes, or pharmacotherapy (Brethauer, Chand, & Schauer, 2006). Some surgical techniques, such as the Roux-en-Y Gastric Bypass (RYGB), have demonstrated good efficacy as far as ten years following the procedure (Valezi, de Almeida Menezes, & Mali, 2013). Moreover, bariatric surgery is associated with a reduction or, in some cases, complete resolution of associated medical comorbidities (Deitel, 2002; Gami, Caples, & Somers, 2003; Mechanick
et al., 2013) and reduction in all-cause mortality (Sjostrom, 2008). However, weight loss begins to slow around 18-24 months following surgery, and a subsample of patients begin to show evidence weight regain (range: 15%-50%) from that point going forward (Magro et al., 2008; Mechanick et al., 2013; O'Brien, Dixon, & Brown, 2004; Odom et al., 2010; Sjostrom et al., 2007).

Postoperative studies of patients who evidence weight regain or suboptimal weight loss following bariatric surgery suggest a number of putative factors including metabolic adaptations, anatomical variations, hormonal permutations, and other biological factors. However, the majority of studies have examined behavioral and psychosocial factors including psychopathology, maladaptive eating behaviors, and poor cognitive functioning (Conceição et al., 2014; El Chaar et al., 2011; Gould, Beverstein, Reinhardt, & Garren, 2007; Poole et al., 2005; Spitznagel et al., 2014). For this reason, presurgical psychological evaluations (Block & Sarwer, 2013) attempt to identify patients who are at risk for engaging in maladaptive postoperative behavior; however, in some prospective studies preoperative psychiatric diagnoses and psychological testing results have not been consistently linked to suboptimal weight loss, weight regain, or redevelopment of maladaptive behaviors following surgery (Engel, Mitchell, de Zwaan, & Steffen, 2012; Kalarchian et al., 2008; Suzuki, Haimovici, & Chang, 2012). Recent developments in psychodiagnostic practice, intended to address the challenge of psychopathology comorbidity, may provide guidance toward understanding and resolving these inconsistencies. These developments involve the emergence of structural psychopathology models (Kotov, Chang, et al., 2011; Kotov, Ruggero, et al., 2011; Krueger & Markon, 2006; Krueger, Markon, Patrick, Benning, & Kramer, 2007;
Sellbom, Ben-Porath, & Bagby, 2008; Watson, 2005) that account for diagnostic comorbidity, which, for reasons detailed later may have hampered prior efforts to identify presurgical psychological risk factors for poor bariatric surgery outcomes.

The goal of this dissertation is to advance the study of presurgical psychological functioning and postoperative outcomes in bariatric surgery patients by using contemporary, structural models of psychopathology to predict non-linear BMI-reduction 5-years following gastric bypass surgery. Psychosocial factors that have been linked to various problematic postsurgical, behavioral outcomes (e.g., dietary non-adherence) and, ultimately, suboptimal weight loss are reviewed first, with a focus on how psychopathology has been conceptualized and assessed in this research. A discussion of the ubiquitous challenge of psychopathology comorbidity and the consequent emergence of empirically-supported structural models of psychopathology follows. It is then proposed that the role of psychological dysfunction in bariatric surgery outcomes will best be captured by relying on measures linked to these contemporary hierarchical models of psychopathology, which may better account surgical outcomes. Next, empirical analyses will test whether contemporary, hierarchical models of psychopathology replicate in a sample of gastric bypass patients using data derived from their pre-surgical evaluation. Patients’ BMIs across five-years will modeled using a structural equation modeling approach that can incorporate individual variability and is flexible with non-normal trajectories and missing data over time. The pre-surgical, hierarchical models of psychopathology will then be used as predictors of variability in the rate of BMI-reduction over time and in 5-year BMIs. A discussion of the findings and their implications will follow.
Overview of Bariatric Surgery: Benefits, Risks, and Procedures

In the last few decades, surgeons have utilized a number of well-studied bariatric surgery procedures: the Vertical Band Gastrectomy (VBG), the Laparoscopic Adjustable Gastric Band (LAGB), the Roux-en-Y Gastric Bypass (RYGB), and the Sleeve Gastrectomy (SG). Variability in weight loss associated with bariatric surgery can depend, in part, on the surgical technique used (Li, Fisher, Dutta, O’Brien, Ackerson, Sorel, & Sidney, 2015). In addition, because foods and liquids bypass over two-thirds of the stomach as a result of some of these procedures, resulting anatomical changes may influence how alcohol and psychiatric medications are absorbed into the bloodstream. The four techniques and associated anatomical changes are reviewed in this section.

All bariatric surgery procedures are associated with weight loss, improved cardiac functioning, decrease in hypertension, and elimination or improvement in sleep apnea and Type 2 Diabetes (Deitel, 2002; Gami et al., 2003). Additionally, bariatric surgery is correlated with improvements in postoperative sexual functioning and reproduction (Bond et al., 2011), including fewer complications during pregnancy compared to those who are morbidly obese (Bebber et al., 2011). Along with these benefits, there are risks associated with bariatric surgery. Common among all the procedures are risks associated with anesthesia, bleeding, and trauma to internal organs (Byrne, 2001; Elliot, 2003). Other complications include intestinal leaks, bowel obstruction, infection, and persistent nausea and vomiting (Latifi, Kellum, DeMaria, & Sugerman, 2002). Although understudied, plugging – when food becomes stuck in the small outlet from the surgically
created pouch – is experienced by a majority of patients (~76.3%) and often leads to self-induced vomiting (de Zwaan et al., 2010).

VBG was once the most popular surgical technique for rapid weight loss. It consists of surgically creating a vertical window (pouch) below the esophagus (stoma) that can hold one oz. of solid food (Goldberg, Rivers, Smith, & Homan, 2000). A band is then placed around the pouch, thus limiting how much a person can eat. Moreover, the procedure is reversible, the anatomy is left intact, and the procedure is not associated with malabsorption. Although there are a few advantages to the VBG, the procedure is no longer commonly because research has identified a number of disadvantages. Specifically, weight loss one year following the procedure has been deemed suboptimal, because, on average, patients lose only 30-40% of their excess body weight (Brolin, Robertson, Kenler, & Cody, 1994). Additionally, staple line failure (when the surgical staple breaks) rates were high and were substantially associated with a need for revision of the surgery and weight regain (Goldberg et al., 2000; Sugerman, 2001).

LAGB is a restrictive procedure similar to VBG. A band is placed around the upper portion of the stomach creating a small pouch. A reservoir is placed under the skin through which fluid can be injected to adjust the band size (Favretti et al., 2002). Like VBG, LAGB is reversible, does not manipulate the digestive anatomy, and can be adjusted to maximize weight loss (Busetto et al., 2005; Favretti et al., 2002). However, the procedure also requires frequent follow-up visits, and is associated with suboptimal weight loss (~38% Excess Weight Loss after 2 years). Other problems include erosion or slippage of the band and port leakage (Boza et al., 2010; Busetto et al., 2002; DeMaria et al., 2010).
RYGB is the most commonly used technique to date (Mitchell, Garcia, de Zwaan, & Horbach, 2012). The surgeon creates a gastric pouch and combines it with a bypass of the first part of the small intestine, using a transection (vs. a vertical) of the staple line to minimize staple line failure (Mason & Ito, 1969; Mitchell et al., 2012). It is a more efficacious procedure for weight loss compared to the previously described techniques (Mitchell et al., 2012). One year following the procedure, patients can expect to lose 50% or more of their excess weight (Boza et al., 2010; Mitchell et al., 2012). Moreover, a majority of patients maintain their weight loss up to 10 years following the procedure (Valezi et al., 2013). However, because the anatomy of the digestive system is altered, common surgical side-effects include nutritional deficiencies and problems with malabsorption with a number of vitamins and minerals, such as B12, magnesium, calcium, and iron (Byrne, 2001; Elliot, 2003; Koch & Finelli, 2010; Latifi et al., 2002; Ziegler, Sirveaux, Brunaud, Reibel, & Quilliot, 2009). Moreover, nutritional deficiencies in pregnant women following RYGB have been associated with low birth weight of infants that may be a result of nutritional growth restriction during pregnancy (Santulli et al., 2010). In addition to nutritional deficiencies, one-year postoperative bariatric surgery patients who underwent RYGB have been found to absorb significantly less of an antidepressant (Zoloft) than their match-controlled counter-parts (Roerig et al., 2012; Roerig et al., 2013). Furthermore, patients may also experience dumping syndrome as a side-effect of the RYGB. Dumping Syndrome is defined as the rapid gastric emptying of contrast material (Engel et al., 2012). Early Dumping Syndrome occurs 30 minutes after a meal and results in nausea, bloating, abdominal cramps, and explosive diarrhea (Jordan, Overton, & De Bakey, 1957) whereas Late Dumping Syndrome occurs 1 – 3 hours after a
meal and is a result of hypoglycemia due to an exaggerated release of insulin. Late Dumping Syndrome results in flushing, dizziness, palpitations, and an intense desire to lie down (Holst, 1994). Approximately, 50%-70% of patients experience dumping syndrome following gastric bypass (Mallory, Macgregor, & Rand, 1996). Symptoms associated with dumping syndrome tend to subside after 15-18 months postoperative (Ukleja, 2005).

SG is a less studied surgical procedure where 75-80% of the stomach is excised (Abu-Jaish & Rosenthal, 2010; Karmali, Schauer, Birch, Sharma, & Sherman, 2010; Roa et al., 2006). It was originally developed for patients who required a minimal amount of time under anesthesia (Mitchell et al., 2012). SG yields comparable weight loss outcomes to RYGB (Alqahtani, Antonisamy, Alamri, Elahmedi, & Zimmerman, 2012). Additionally, it is associated with minimal malabsorption complications (Alqahtani et al., 2012). On the other hand, the stomach is susceptible to stretching out and leakage from the operation is possible (Abu-Jaish & Rosenthal, 2010; Karmali et al., 2010; Roa et al., 2006).

Overall, bariatric surgery for morbid obesity has demonstrated efficacy for weight loss and reductions in a number of medical comorbidities regardless of the procedure used. However, variability in outcome can be dependent on the technique. Moreover, anatomical changes affect not only how much food the patient can consume, but also how medication and alcohol are absorbed. Consequently, weight loss as a function of surgery type should be considered and controlled for in studies of how non-surgical factors predict outcome.
1.3 Psychosocial Factors Associated with Suboptimal Bariatric Surgery Results

Post-operative studies of patients who evidence weight regain or suboptimal weight loss following bariatric surgery suggest that poor results are associated with depression-related symptoms, substance use, maladaptive eating behaviors, and poor cognitive functioning (Colles, Dixon, & O'Brien, 2008; Heneghan, Heinberg, Windover, Rogula, & Schauer, 2012; Sarwer, Allison, Bailer, Faulconbridge, & Wadden, 2013; Spitznagel et al., 2014; Suzuki et al., 2012). Moreover, presurgical prevalence of psychiatric disorders is higher among bariatric surgery candidates than in the general population (Kalarchian et al., 2007; Marek et al., 2013; Mitchell et al., 2012).

Consequently, the American Association of Clinical Endocrinologists (AACE), the American Society for Metabolic and Bariatric Surgery (ASMBS), and The Obesity Society (TOS) Guidelines for the Clinical Management of Bariatric Surgery Patients (Mechanick et al., 2013) recommend that a multidisciplinary assessment of bariatric surgery candidates that includes presurgical psychological evaluations (Block & Sarwer, 2013) to be conducted.

Presurgical psychological screening is a risk assessment that aims to identify factors that may diminish positive surgical outcomes. For example, the AACE/ASMBS/TOS guidelines recommend that presurgical psychological evaluations include a clinical interview, objective psychometric testing, and a review of patients’ medical charts (Mechanick et al., 2013). An important goal of presurgical psychological screening is to optimize surgical readiness and outcomes. If risk factors (e.g., disordered eating) are identified, preoperative intervention and/or risk-focused postoperative care may be implemented to improve surgical outcomes. In some (rare) cases, alternative
treatment approach may be indicated. However, prospective studies of the association between presurgical findings and postoperative outcomes have yielded inconsistent results (Livhits et al., 2012).

Specific findings on associations between depression/anxiety, maladaptive eating behaviors, alcohol/substance use, and cognitive functioning and post-surgery weight are reviewed next. To consolidate findings and provide a quantifiable metric to assess the extent to which psychosocial risk factors predict weight loss, Cohen’s d will be calculated for studies where data needed to calculate an effect size are reported. By convention, d values of .20, .50, and .80 correspond to a small, medium, and large effect size, respectively (Cohen, 1988).

### 1.3.1 Depression/Anxiety

Depression- and anxiety-related disorders are substantially prevalent in preoperative bariatric surgery patients (de Zwaan et al., 2011; Kalarchian et al., 2007; Marek et al., 2013; Mitchell et al., 2012). Specifically, up to 15.6% meet diagnostic criteria for a depression-related disorder and up 24% satisfy criteria for an anxiety-related disorder at the time of their evaluation. This compares with epidemiological findings of 9.5% and 18.1%, respectively, in the general population (Kessler, Chiu, Demler, Merikangas, & Walters, 2005). Prevalence rates are even higher for lifetime disorders. Specifically, up to 45.5% of bariatric surgery candidates meet criteria for a depression-related disorder and up to 37.5% qualify for an anxiety-related disorder. Although high prior to surgery, prevalence of depression-related disorders has been reported in some studies to decrease for up to three years following bariatric surgery (de Zwaan et al., 2011). However, depression has also been reported to increase significantly after surgery.
in other investigations (Mitchell et al., 2014). In contrast, the prevalence rate for anxiety-related disorders does not appear to change significantly across time (de Zwaan et al., 2011).

Understanding the role of mood-related symptoms is of particular importance because the rate of postoperative suicide in bariatric surgery patients is higher than in the general population (Heneghan et al., 2012; Tindle et al., 2010). Heneghan et al. (2012) reported modest associations between an increased risk in suicide and obesity across a number of studies. Moreover, they noted that the association persists after treatment for obesity. Mitchell et al. (2013) have postulated that if the procedure fails to meet patients’ expectations, outcome-related distress may play a role in this finding. Other factors that are not well studied in the postoperative literature, but may contribute to an increased risk of suicide following surgery, include body image dissatisfaction, concerns about loose redundant skin, and the absorption rates of psychotropic antidepressant medications following surgery (Roerig et al., 2012; Roerig et al., 2013).

Studies of association between presurgical depression/anxiety disorders and postoperative outcomes have yielded inconsistent findings. For example, Semanscin-Doerr, Windover, Ashton, and Heinberg (2010) examined whether a lifetime unipolar or bipolar mood disorder was predictive of poorer weight loss outcomes in a sample of 104 bariatric surgery patients undergoing a Sleeve Gastrectomy. Those with a lifetime depressive disorder lost significantly less weight one (d = .37), nine (d = .46), and twelve months (d = .54) post-surgery than did patients with no lifetime psychiatric disorders. Patients who met criteria for a current mood disorder at the time of their presurgical psychological evaluation also lost less weight than those with no history of, or current
mood disorder at one (d = .64), three (d = .70), six (d = .71), nine month (d = .70), and one-year follow-up (d = .40), though the latter was not statistically significant.

Kalarchian et al. (2008) examined whether patients who underwent a RYGB diagnosed with a current or lifetime mood/anxiety disorder lost less weight than patients with no psychiatric diagnosis six months following a RYGB. These researchers found that patients with a lifetime mood disorder had lesser BMI-reductions at the six-month follow-up compared to patients who had no psychiatric diagnosis, after controlling for gender, race, and age (d = .32). A similar finding was reported for patients with a lifetime anxiety disorder (d = .28). Although results reported by Kalarchian et al. (2008) were associated with smaller effect size coefficients compared to findings reported by Semanscin-Doerr et al. (2010), the associations may have been attenuated due to surgery type. Kalarchian et al. (2008) also found that there were no BMI reduction differences at the six month follow-up (d = .17) between those who met criteria for any current Axis I disorder at the time of their pre-surgical evaluation and those who met criteria for no psychiatric diagnosis prior to surgery.

In another study of RYGB patients, de Zwaan et al. (2011) conducted structured diagnostic interviews both pre-surgically and at two follow-up time points: between six and twelve months and between two to three years following surgery. Data needed to compute effect sizes were not reported in their investigation. Consistent with Kalarchian et al. (2008), de Zwaan et al. (2011) found no association between current depression-related disorders and weight loss at any time point, but found lifetime depression-related disorders were negatively associated with weight loss at follow-up. However, individuals
who met criteria for both a mood and anxiety disorder (lifetime and current) prior to surgery had poorer weight loss when compared with those with no diagnoses.

Presurgical scores on psychometric measures of depression and anxiety have generally not been found to be associated with postoperative weight loss, and in some studies, an unexpected positive association has been reported, with higher scores related to better weight loss outcomes. For example, studies using scales derived from Minnesota Multiphasic Personality Inventory (MMPI) instruments (Ben-Porath & Tellegen, 2008/2011; Butcher, Graham, Ben-Porath, Tellegen, & Dahlstrom, 2001; Hathaway & McKinley, 1943; Tellegen & Ben-Porath, 2008/2011) have yielded inconsistent findings, with some investigations reporting no associations between presurgical scores on scales that assess depression/anxiety–related symptoms and poor postoperative weight loss and others reporting up to a medium effect size (ds = .04 - .52) (Barrash, Rodriguez, Scott, Mason, & Sines, 1986; Marek et al., 2015; Tarescavage, Wygant, Boutacoff, & Ben-Porath, 2013; Tsushima, Bridenstine, & Balfour, 2004).

Using other measures, Averbukh et al. (2003) reported a positive association between presurgical Beck Depression Inventory – II (BDI-II) (Beck, Steer, & Brown, 1996) scores and one year weight loss success in a sample of 145 RYGB patients. Odom et al. (2010) also reported that higher presurgical BDI-II scores were associated with a lower risk for weight regain one-year post-surgery in a sample of 203 RYGB patients.

Some differences that might explain the inconsistent findings in these studies include the time period for which weight loss was assessed and how it was reported. For example, Tarescavage et al. (2013) reported BMI change one year following surgery whereas Odom et al. (2010) examined associations with weight loss outcomes between
12 and 30 months post-surgery. Another source of inconsistency is surgery type reported in these studies. Tsushima et al. (2004) reported one-year outcome findings in a sample of patients who underwent a RYGB whereas Tarescavage et al. (2013) combined surgery types (Vertical Gastric Banding and RYGB). When comparing studies such as Averbukh et al. (2003) and Tsushima et al. (2004) who both reported one-year weight loss outcomes using in a sample of RYGB, the inconsistent results appear to be attributed to the method used to assess depression (BDI-II vs. MMPI-2), raising the possibility that depression-related symptoms are assessed differently across these instruments.

In summary, the literature includes inconsistent research findings on associations between presurgical depression and anxiety-related problems and weight loss following bariatric surgery. To some extent, these discrepancies may reflect different sample sizes used across studies. Although some investigators reported non-significant findings, many of the studies reviewed in this section, including some that reported a lack of statistically significant associations, yielded clinically meaningful effect sizes (using structured interviews and psychological measures), raising the possibility that Type II errors may play a role in these inconsistencies. Relatedly, none of the studies reviewed in this section used missing data techniques. Instead, they relied on listwise/pairwise deletion methods for longitudinal analyses. It is possible that patients who had lifetime depression or anxiety-related disorders were also more likely not to return to follow-up because their symptoms inhibited them from doing so (e.g., vegetative symptoms of depression may have interfered with motivation to return to a follow-up session).
1.3.2 Maladaptive Eating

Obese individuals tend to report higher frequencies of maladaptive eating, some of which meet criteria for Binge Eating Disorder (BED) and Night Eating Syndrome (NES). BED and NES occur in up to 2.4% and 1.5% the general population, respectively (Hudson, Hiripi, Pope, & Kessler, 2007; Rand, Macgregor, & Stunkard, 1997). To have met criteria for BED outlined in the Diagnostic and Statistical Manual of Mental Disorders 4th Edition (DSM-IV-TR) (APA, 2000), a patient had to report at least two objective binge eating episodes per week and a sense of “loss of control” during these episodes, for at least six months. In addition, a patient had to experience distress in regards to binge eating and meet at least three other criteria, such as: eating when not physically hungry, eating until he or she felt uncomfortably full, eating more rapidly than normal, eating alone due to embarrassment over eating, or feelings of disgust/guilt at the conclusion of binge eating episode. In DSM-5 (APA, 2013), the criteria for diagnosing Binge Eating Disorder were changed to one objective binge eating episode per week and report of a sense of “loss of control” during binge eating episodes, for at least three months. Although the criteria for BED were relaxed substantially, the change in prevalence in bariatric surgery candidates is negligible (Marek, Ben-Porath, Ashton, & Heinberg, 2014a). NES is characterized as awakening from sleep to eat, or engaging in excessive food consumption after the last meal of the day. In addition, three of the following symptoms must be reported: morning anorexia, subjective urges to eat after the last meal of the day, belief that one must eat in order to fall back to sleep at night, depressed mood, or difficulty sleeping. NES is included in the “Other Specified Feeding or Eating Disorder” category of the DSM-5 (APA, 2013).
Among bariatric surgery patients, the frequency of binge eating ranges from 6% to 64% (Niego, Kofman, Weiss, & Geliebter, 2007). Moreover, the prevalence rate for BED as outlined in the DSM-IV-TR and DSM-5 ranges from 10.1% to 27.1% (Kalarchian et al., 2007; Marek, Ben-Porath, et al., 2014a; Marek, Ben-Porath, Ashton, & Heinberg, 2014b; Marek et al., 2013; Mitchell et al., 2012). This is the most common presurgical psychiatric disorder in the bariatric surgery population. However, as with the mood and anxiety disorders, the literature on associations between presurgical BED and bariatric surgery outcomes is inconsistent. Some authors have reported that presurgical BED is associated with poorer weight loss outcomes between six months and two years following bariatric surgery, ($d = .50 \rightarrow 1.09$) (Green, Dymek-Valentine, Pytluk, le Grange, & Alverdy, 2004; Hsu, Sullivan, & Benotti, 1997). However, a majority of studies indicate that presurgical BED status is unrelated to weight loss during this time period ($d = .09 \rightarrow .30$) (Buzetto et al., 2005; Green et al., 2004; White, Masheb, Rothschild, Burke-Martindale, & Grilo, 2006). The studies just cited had various methodical limitations including, among others: small sample size, not accounting for missing data across time, retrospective assessments, and not relying on structured interviews.

Because some evidence suggests that BED may be a risk factor for poorer weight loss, researchers have begun to examine maladaptive eating behaviors more broadly, in an effort to better understand the factors associated with uncontrolled eating that may contribute to poorer surgical outcomes. For example, maladaptive eating patterns that have contributed to weight regain in bariatric surgery candidates, such as poor dietary adherence, are also associated with weight regain in individuals receiving non-surgical weight loss treatment (Cummings & Lentendre, 2009; Orth, Madan, Taddeucci, Coday,
More specifically, some investigators have begun to examine whether a particular component of BED, loss of control over eating (LOC), may account for associations between weight loss and eating behavior outcomes. LOC is defined in DSM-5 as “a sense of lack of control over eating during the episode (for example, a feeling that one cannot stop eating or control what or how much one is eating)” (APA, 2013; p. 350). LOC is prevalent both prior to and up to 10 years following bariatric surgery. In a sample of 437 bariatric surgery patients, Kofman, Lent, and Swencionis (2010) reported that 49.9% of postoperative patients between three and ten years after surgery indicated that they either had a difficult time stopping eating or tended to lose control over what they were eating. Of these individuals, 18% reported subjective experience of loss of control over eating – a prevalence rate that is similar to preoperative BED rates in this population. 46% of these patients also reported grazing (eating smaller amounts of food over a long period of time).

White, Kalarchian, Masheb, Marcus, and Grilo (2010) examined associations between LOC and postoperative weight loss, quality of life, depression, and eating-disordered psychopathology. Self-report assessments were conducted at four time points: prior to surgery, and six months, one year, and two years following surgery. Preoperative LOC was associated with higher presurgical and postoperative BDI scores, eating-disorders, and quality of life. In addition, preoperative LOC predicted postoperative LOC across all time points. Preoperative LOC did not predict postoperative weight loss. Specifically, the association between preoperative LOC and weight loss at six (d = .20), twelve (d = .14), and twenty-four months (d = .07) post-surgery did not approach statistical significance. However, postoperative assessments of LOC were positively
associated with weight regain between one and two years post-surgery (d = .62). In another study, Saunders (2004) assessed patients’ binge and grazing habits in addition to LOC both prior to surgery and at six months after. Grazing is an eating behavior defined by “the repetitive eating of small to modest amounts of food in an unplanned manner and/or not in response to hunger/satiety sensations” (Conceição et al., 2014, p. 979). Eighty percent of patients who reported LOC and associated behaviors prior to surgery also reported LOC three to five times per week six-months post-surgery, and grazing became more of a common pattern. Conceição et al. (2014) reported that grazing significantly predicted weight regain two years after surgery (d = 1.6). Grazing is beginning to emerge as a potential risk factor for poor weight loss and weight regain in bariatric surgery patients; however, empirically-supported tools and recommendations for assessing this behavior are lacking.

Taken together, recent research has not consistently supported the notion that a preoperative diagnosis of BED is related to suboptimal weight loss results. However, studies that reported no statistically significant associations between presurgical BED and weight loss outcomes were hampered by a number of methodological limitations. As discussed in the mood/anxiety section, many of the BED studies did not appropriately handle missing data across time and/or relied on relatively small samples. Effect sizes across a majority of these studies ranged from small to large and likely did not reach statistical significance, due to Type II Error. Assessment of other eating habits (such as grazing) and LOC appears to adequately and consistently predict diminished results across time, though further research on these variables is warranted.
1.3.3 Alcohol/Substance Use

Alcohol and substance use have received a substantial amount of attention in the bariatric surgery literature. More recent research has focused on altered pharmacokinetics of alcohol following surgery and the increased post-operative risk of Alcohol Use Disorders (AUD). Although current prevalence rates for Substance Use Disorders in bariatric surgery candidates are lower than the general population (Mitchell et al., 2012), the lifetime prevalence rate for these disorders is 33.2% (Mitchell et al., 2012), more than twice as high as the general population (Kessler & Merikangas, 2004). Identification of, and intervention for, AUD in bariatric surgery candidates is critical because significant weight loss has an inverse association with blood ethanol concentration.

Pharmacokinetic changes following RYGB further accelerates alcohol absorption. The reduced volume of the stomach results in less alcohol dehydrogenase and a faster absorption of alcohol, making Substance Use Disorders particularly problematic in bariatric surgery patients. In a case-crossover study, Woodard, Downey, Hernandez-Boussard, and Morton (2011) measured blood alcohol content (BAC) using breathalyzer recorders (BrAC) preoperatively and three and six months postoperatively in a small sample of RYGB patients. Participants drank 5 ounces of red wine at each time point. At follow-up, BAC was more than 3.5 times higher (0.088%) six months after surgery (above the legal limit for operating a motor vehicle in most states) than before (0.024%).

In regards to the physiological effects of other illicit substances following bariatric surgery, only one case study of an 18-year-old RYGB patient has been published (Choi & Scarborough, 2004). The patient had abused cocaine both before and after surgery and experienced a stroke four months following the procedure.
In a number of longitudinal studies, the prevalence rate for postoperative AUD increased significantly when compared with preoperative rates (King et al., 2012; Mitchell et al., 2001). King and colleagues (2012) examined pre and postoperative AUD in a sample 2,458 RYGB patients across ten different bariatric surgery clinics. Prevalence rates for current AUD did not significantly differ between the preoperative (7.6%) and one-year postoperative (7.3%) evaluations. However, the prevalence rate significantly increased at the two-year assessment (9.6%). Significant presurgical predictors of AUD following surgery were being male, younger age, regular cigarette and alcohol consumption (≥2 drinks per week), a presurgical diagnosis of AUD, regular illicit substance use, and poor interpersonal support. In another longitudinal study, Mitchell et al. (2001) reported Alcohol Abuse and Dependence Disorder prevalence rates both prior to and 13-15 years following surgery in a sample of 100 RYGB patients. The researchers reported an increase in AUD rates over time (2.6% pre-surgery to 5.1% after) but a decrease in Alcohol Dependence Disorder (10.3% pre-surgery to 2.6% after surgery). In another longitudinal study consisting of 70 RYGB patients, Ertelt et al. (2008) reported Alcohol Abuse and Dependence Disorder prevalence rates both prior to and 6-10 years following surgery. Of the total sample, 7.1% met criteria for Alcohol Dependence and 1.4% met criteria for Alcohol Abuse prior to surgery. At the postoperative follow-up, prevalence rates were unchanged; however, 2.9% of bariatric surgery patients who reported no problems with alcohol prior to surgery met criteria for Alcohol Dependence at the postoperative time point. Although, overall, the literature indicates the prevalence for AUD increases after bariatric surgery, these rates are lower than those found in the general population (Kessler et al., 2005).
Because, as just discussed, alcohol metabolizes differently and prevalence rates appear to increase after surgery, understanding how Substance Use Disorders contribute to bariatric surgery outcome is of particular importance. Research to date has only examined weight loss as a dependent variable in this area. Clark et al. (2003) reported 2-year postoperative percent excess weight loss (%EWL) in a sample of 80 bariatric surgery patients. Patients who had either met criteria for a Substance Use Disorder or had a history of substance use treatment were compared to those who either had no psychiatric treatment history or psychiatric comorbidity two years following a RYGB. Overall, patients with a history of psychiatric treatment for substances or those who had a Substance Use Disorder prior to surgery had a greater %EWL than those who had not met criteria for any psychiatric disorder (d = .75) or had a prior psychiatric treatment history (d = .83). Similarly, Heinberg and Ashton (2010) reported that reductions in BMI 6 (d = .72), 9 (d = .68), and 12 (d = .60) months following bariatric surgery were greater for patients who had a history of substance abuse/dependence diagnoses as compared to individuals who did not meet criteria for a Substance Use Disorder. Although the difference was statistically non-significant at the one year follow-up, a modest to large effect size was reported. These differences were also observed after controlling for presurgical BMI and type of surgical procedure used. Another study by Dixon, Dixon, and O'Brien (2001) reported patients who engaged in regular alcohol consumption lost more weight at follow-up than those who reported no alcohol use prior to surgery (d = 1.09).

Although the studies just reviewed indicate better weight loss outcomes for patients who have a history of substance-related disorders, other literature suggests there
are no weight loss differences when comparing patients with and without a history of a Substance Use Disorder across various surgery types (Black, Goldstein, & Mason, 2003; Kopec-Schrader, Gertler, Ramsey-Stewart, & Beumont, 1994; Sears, Fillmore, Bui, & Rodriguez, 2008; Suzuki et al., 2012). Of the studies that reported Substance Use Disorder was unrelated to weight loss, only (Black et al., 2003) reported information needed to calculate an effect size (d = .45).

Overall, the literature on whether a history of Substance Use Disorder predicts poorer weight loss outcomes is mixed. However, because absorption rates differ dramatically following surgery and patients who met criteria for a Substance Use Disorder are also likely to meet criteria for the disorder one and two years after surgery, other outcome variables, such as medical morbidity should be considered. Moreover, it is possible that bariatric surgery patients who do not make lifestyle changes in regards to their substance use, may fail to make other lifestyle changes, such as in their dietary regimens, which may impact their functioning long term.

1.3.4 Cognitive and Thought Dysfunction

Cognitive deficits are associated with obesity across the lifespan, particularly in the areas of attention, executive functioning, and memory (Gunstad, Mueller, Stanek, & Spitznagel, 2012). Medical co-morbidities linked to obesity, such as Type 2 Diabetes, obstructive sleep apnea, and hypertension are also associated with deficits in the neurocognitive domains just mentioned (Aloia, Arnedt, Davis, Riggs, & Byrd, 2004; Kumar, Anstey, Cherbuin, Wen, & Sachdev, 2008; Raz, Rodrigue, & Acker, 2003). Therefore, it is important to consider how bariatric surgery affects neuropsychological
functioning as well as how cognitive functioning predicts outcomes following bariatric surgery.

Executive functioning, defined as a higher-order cognitive ability associated with planning and self-control (Lezak, Howieson, Bigler, & Tranel, 2012), is gaining considerable attention in the maladaptive eating and obesity literature. Deficits in this area are associated with impulsivity (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001), a construct related to maladaptive eating patterns (Haedt-Matt & Keel, 2011; Mobbs, Crepin, Thiery, Golay, & Van der Linden, 2010; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006), including LOC, which as discussed earlier is associated with increased risk for maladaptive eating patterns following bariatric surgery (Colles et al., 2008; de Zwaan et al., 2010). Although there is limited research examining the role of executive functioning and maladaptive eating behaviors in bariatric surgery patients, studies have examined these associations in other samples. In a study comparing obese vs. lean individuals, Calvo, Galioto, Gunstad, & Spitznagel (2014) found modest to large negative associations between high disinhibition scores on the Three-Factor Eating Questionnaire (TFEQ-R18lKarlsson, Persson, Sjostrom, & Sullivan, 2000) and measures of executive functioning (ds = .56 - .73). Obese individuals also demonstrated slower inhibitory control when compared to lean individuals (d = .74). These results were similar to those reported by Maayan, Hoogendoorn, Sweat, and Convit (2011) who used a comparable methodology with a sample of adolescents.

Some studies demonstrate that executive functioning deficits are more pronounced in obese individuals diagnosed with BED when compared to obese individuals who do not meet the diagnostic threshold for BED (Duchesne et al., 2010;
Svaldi, Brand, & Tuschen-Caffier, 2010). Conversely, some research has found no differences in executive functioning or other cognitive domains between morbidly obese individuals with or without BED (Galioto et al., 2012) or in bariatric surgery patients irrespective of a BED diagnosis (Lavender et al., 2014). Because executive functioning is associated with both disinhibition related to eating and BED in other obese samples, it is an important construct to consider in bariatric surgery candidates.

Other cognitive domains such as attention and memory have been found to be related to postoperative outcomes. Gunstad et al. (2011) reported both presurgical cognitive functioning scores and one-year postoperative scores in a sample of 150 bariatric surgery patients and 41 obese control participants. Both bariatric surgery candidates and obese controls yielded scores that indicated clinically meaningful impairment in attention, executive functioning, memory, and language. When examining changes in scores across time, bariatric surgery patients showed improved performance in all cognitive domains in comparisons with obese control participants. Evidence of improved memory performance was also reported two years following bariatric surgery utilizing a similar methodology (Alosco et al., 2014).

In another study, Spitznagel, Garcia, et al. (2013) examined whether cognitive functioning predicted weight loss three and twelve-month post-surgery. A total of 84 bariatric surgery patients were assessed at baseline and 71 patients returned for follow-up testing. As expected, participants showed deficits in domains of attention, executive functioning, and memory. Baseline cognitive functioning did not predict three-month weight loss; however, improvements in test scores from baseline predicted better weight loss outcomes at the one-year follow-up. It has also been suggested that cognitive
functioning may mediate the association between dietary adherence and weight loss outcomes in bariatric surgery candidates (Galioto, Gunstad, Heinberg, & Spitznagel, 2013). Empirical evidence indicates that poorer performance on presurgical cognitive testing in the domains of attention, executive functioning, and memory is associated with poorer self-reported dietary adherence four to six weeks following surgery (ds = .72 – 1.35) (Spitznagel, Galioto, & Limbach, 2013).

Researchers also found that presurgical cognitive test performance predicts long-term weight loss outcomes (≥ 2 years). Spitznagel, Alosco, et al. (2013) tested 51 bariatric surgery patients at baseline and at one-year and two-year follow-up. After controlling for baseline scores, improvements in the domains of attention and executive functioning at the one-year follow-up predicted better weight loss outcomes at the twenty-four-month follow-up (d = .67). In a three-year outcome study, Spitznagel et al. (2014) hypothesized that one-year postoperative cognitive deficits would predict weight loss outcomes at the 36-month follow-up. After controlling for gender, presurgical cognitive test performance, and one-year weight loss outcomes, deficits in working memory, recognition memory, and generativity (defined as the ability to fluidly produce new ideas relative to specific criteria) significantly predicted poorer weight loss outcomes at follow-up (d = 1.12).

Limited research has examined whether bariatric surgery is safe and effective for patients diagnosed with thought disorders, such as Schizophrenia. This is because these patients are often not recommended for bariatric surgery despite the lack of research to support this decision (Hamoui, Kingsbury, Anthone, & Crookes, 2004). To date, only one study has examined whether patients diagnosed with Schizophrenia and treated with
antipsychotic medications could achieve similar weight loss outcomes compared to a matched-control group (Hamoui et al., 2004). At the six-month post-surgical follow-up, both groups exhibited similar weight loss outcomes. The authors cautioned, however, about long term outcomes because many antipsychotic medications are associated with weight gain.

In summary, deficits in the areas of memory, attention, and executive functioning improve following bariatric surgery. As reviewed, deficits in these areas predict both suboptimal weight loss and dietary non-adherence following surgery. Associations between cognitive functioning, specifically executive functioning, and poor weight loss outcomes and adherence may reflect a third variable—Externalizing Dysfunction (a construct encompassing impulsivity, risk-taking behaviors, heightened activation, aggressiveness, etc.). Moreover, there is a dearth of literature that explores whether bariatric surgery is safe and effective for patients who present with a thought disorder. Future work in the area should both replicate these results and examine associations between these cognitive domains and LOC eating, substance abuse, and other Externalizing Dysfunction in bariatric surgery patients.

1.3.5 Summary

A number of studies were reviewed that sought to examine whether presurgical depression/anxiety, eating behaviors, substance use, and cognitive functioning predicts postoperative weight loss. Studies that relied on presurgical diagnoses of a mood or anxiety disorder have yielded inconsistent findings (c.f., de Zwaan et al., 2011; Kalarchian et al., 2008; Semanscin-Doerr et al., 2010). Data obtained with psychological assessment instruments have also produces mixed results, where some authors reported
higher presurgical scores on the BDI-II predict positive weight loss outcomes (c.f., Averbukh et al., 2003; Odom et al., 2010) whereas scores on instruments such as the MMPI are unassociated or negatively correlated with weight loss outcomes (c.f., Tarescavage et al., 2013; Tsushima et al., 2004).

Although a presurgical diagnosis of BED also produces inconsistent findings across studies, researchers have begun examining more specific uncontrolled eating behaviors, such as grazing and LOC. However, it is difficult to synthesize research on these behaviors due to a lack of empirically-supported and recommended criteria for assessing these maladaptive eating patterns. In terms of AUD, inconsistent conclusions are also drawn from the research in existing literature. Some studies suggest that a presurgical Alcohol Use Disorder predicts greater weight loss outcomes (c.f., Dixon et al., 2001; Heinberg & Ashton, 2010) whereas other investigations suggest the disorder is unrelated to the amount of weight loss achievable by bariatric surgery (c.f., Black et al., 2003; Suzuki et al., 2012). Moreover, the relation between presurgical use of illicit substances and weight loss outcomes is still unclear.

Neurocognitive functioning improves after bariatric surgery; however, presurgical cognitive deficits have been found to be associated with poorer weight loss outcomes for as long as three years post-surgery (Spitznagel et al., 2014). Because many bariatric surgery candidates who exhibit thought disorder are often not recommended for surgery, it is difficult to draw inferences about whether a thought disorder impedes surgical outcomes in this setting.
1.4 The Hierarchical Models of Psychopathology

Although the literature just reviewed has, in some instances, found substantial associations between presurgical psychological functioning and surgical outcomes, a meta-analysis of 115 articles published between 1998 and 2010, Livhits et al. (2012) found minimal to no evidence for associations between postoperative weight loss and the following presurgical psychosocial risk factors: previous weight loss attempts, binge/sweet/maladaptive eating habits, depression, anxiety, history of sexual abuse, self-esteem, history/current alcohol abuse/use, and other psychiatric disorders. The only preoperative psychosocial factor associated with suboptimal weight loss was the presence of a personality disorder. It is possible that the inconsistencies reported across the literature are a result of how psychopathology has been conceptualized and assessed. The following section reviews the problem of psychiatric comorbidity, which has led to emergence of higher-order psychopathology models that may help resolve some of the inconsistencies just noted.

Ambiguous findings, such as those just reviewed, on associations between presurgical psychopathology and postsurgical outcomes of bariatric surgery have been obtained in other areas of psychopathology research. This in turn has led investigators to explore the possible role played by psychiatric comorbidity in difficulties replicating research findings. Hierarchical psychopathology models that better account for comorbidity have emerged from this research, which may assist in clarifying the role of psychological dysfunction in weight loss surgery outcomes.

A categorical-polythetic classification system for mental illness is used worldwide. This approach assumes that psychopathology can be classified into distinct
categories – where meeting a diagnostic threshold is a matter of having a sufficient number and range of symptoms associated with the diagnosis in addition to experiencing distress and impairment related to these symptoms. The system is polythetic in that different combinations of symptoms can result in the same diagnosis. However, this approach to classifying mental illness, as implemented in the DSM and ICD diagnostic systems, creates comorbidity problems (Bogenschutz & Nurnberg, 2000; Maj, 2005a, 2005b; Meehl, 2001). Previously published studies using structured interviews based on DSM-III, DSM-III-R, and DSM-IV diagnoses indicate that mental disorders co-occur far more frequently than would be expected by chance (Brown, Campbell, Lehman, Grisham, & Mancill, 2001; Kessler et al., 2005; Kessler et al., 1994). Relatedly, meeting criteria for only one diagnosis in clinical settings is rare. For example, Kessler et al. (2005) reported that 58% of individuals who met for a current or lifetime Major Depressive Disorder (MDD) or Dysthymic Disorder also met for a current or lifetime anxiety-related disorder.

In an eating disorder and weight management program, 73.8% of patients who met the diagnostic threshold for BED via structured interview also met criteria for at least one other lifetime psychiatric diagnosis (Grilo, White, & Masheb, 2009). Specifically, 54.2% met criteria for criteria for a lifetime mood disorder, 37.1% qualified for a lifetime anxiety disorder, and 24.8% met criteria for a Substance Use Disorder. Moreover, 43.1% of patients with BED met criteria for at least one additional current mood/anxiety disorder. In terms of current disorders, 26% of patients met criteria for a current mood disorder, and 24.5% of patients qualified for a current anxiety disorder. The problem of comorbidity is prevalent in bariatric surgery settings as well. When using structured
interviews in bariatric surgery clinics, 42.7% of patients met criteria for two lifetime disorders and 25.7% met criteria for three mental disorders outlined in the DSM-IV-TR (Kalarchian et al., 2007). Rates of bariatric surgery candidates who met criteria for two or three current DSM-IV-TR diagnoses were 17.0% and 7.6%, respectively.

High comorbidity rates in mental health settings, among individuals with eating disorders, and in bariatric surgery settings, raise two questions: why is this occurring and does this reflect a need for a better way to define and assess psychopathology? Maj (2005a, 2005b) noted that because mental disorders rarely occur in isolation, there is sufficient evidence to suggest that categorical distinctions do not exist in nature. Meehl (2001) argued that a taxonic categorical approach to mental illness would best be conceptualized if we understood the latent structures underlying comorbid disorders. Along these lines, Bogenschutz and Nurnberg (2000) and Kessler (2002) suggested that categorical disorders can best be understood from a dimensional framework, which researchers have sought to model and assess with psychometric measures (c.f., Krueger & Markon, 2006; Markon, Krueger, & Watson, 2005; Watson, 2005; Watson & Tellegen, 1985).

In an effort to account for comorbidity, researchers have been moving toward developing models and measures that conceptualize and assess common features of mental disorders. This research has indicated that various symptoms and behaviors linked with psychopathology are associated with three higher-order, correlated, latent constructs, termed Internalizing and Externalizing (Achenbach, 1966; Krueger, Markon, Patrick, & Iacono, 2005) and thought dysfunction (Kotov, Chang, et al., 2011; Markon, 2010; Wolf et al., 1988). Internalizing Dysfunction encompasses symptoms and
disorders related to mood and anxiety, whereas Externalizing Dysfunction accounts for variance associated with impulse control disorders, antisocial behaviors, and substance use disorders. Although not as prevalent or well-studied among bariatric surgery patients, studies incorporating samples of patients with psychotic disorders indicate a third broad dimension termed Psychoticism or Thought Dysfunction, which captures symptoms related to psychotic disorders such as paranoia, hallucinations, and delusions (Kotov, Chang, et al., 2011; Markon, 2010; Wolf et al., 1988). Moreover, although psychopathology and personality have been previously thought to be distinct (hence the prior distinction between Axis I and Axis II disorders in the DSM), congruence between these hierarchical psychopathology models and dimensional models of personality indicates that broad domains of personality and psychopathology are neither unique nor separable (Harkness, Reynolds, & Lilienfeld, 2014; Krueger & Tackett, 2006). I turn next to a review of the literature on these three dimensions of psychopathology, labeled here Internalizing, Externalizing, and Thought Dysfunction, followed by a discussion of their potential relevance to understanding associations between eating disorders and other manifestations of psychopathology and the possibility that by accounting for comorbidity, these models may assist in clarifying associations between presurgical mental dysfunction and personality and postoperative outcomes in bariatric surgery candidates.

1.4.1 Internalizing Dysfunction

Factor analyses of self-reported mood and anxiety descriptors have indicated the presence of two bipolar dimensions of emotional activation initially termed Positive Affect and Negative Affect (Watson & Tellegen, 1985). These mood-focused constructs
were subsequently relabeled Positive Activation and Negative Activation (Tellegen, Watson, & Clark, 1999). Their personality trait counterparts are often labeled Positive and Negative Emotionality (Tellegen & Waller, 2008). Symptoms associated with low Positive Activation/Emotionality – anhedonia, lack of interest, low energy – are more closely related to MDD whereas symptoms of high Negative Activation/Emotionality – stress reactivity, obsessive rumination, and intrusive ideation – are more closely associated with anxiety-related psychopathology (Panic Disorder, Agoraphobia, and Specific Phobias). Although correlational findings indicate that the two dimensions of Positive Activation/Emotionality and Negative Activation/Emotionality are relatively independent, the shared hedonic features of both constructs reflect a bipolar dimension of happiness-unhappiness, termed pleasant versus unpleasant mood or Demoralization (Frank, 1974; Tellegen, 1985; Tellegen et al., 1999; Watson & Tellegen, 1985). This is a construct that encompasses feelings of dysphoria, pessimism, and experiences of difficulties coping with stress. Demoralization has been investigated as a construct that motivates individuals to seek treatment (Barlow, Allen, & Choate, 2004; Frank, 1974) and conceptualized as a variable that limits discriminant properties of self-report measures of mood and anxiety (Tellegen, 1985). Dohrenwend, Shrout, Egri, and Mendelsohn (1980) noted that demoralization is a dimension of distress not specific to any particular psychiatric disorder. They described assessing it as analogous to taking a patient’s temperature in physical medicine. Although an elevated body temperature indicates that something is wrong, it does not point toward the specific disease that causes it. Klein (1974) provided evidence that what he described as endogenomorphic depression (i.e., biologically-caused depression) was more closely related to actual
deficits in the ability to experience positive emotions and thus, he hypothesized that individuals with anhedonia would be more likely to respond to antidepressants than individuals presenting with demoralization, or generally dysphoric mood.

Building on some of these findings, Krueger (1999) empirically tested a two-factor structure of mood/anxiety disorders and reported evidence of two constructs that were termed anxious-misery and fear. Watson (2005) revised this model and proposed a higher-order internalizing factor (termed Negatave Affectivity) that bifactuates into two lower order factors, distress and fear. In this model, the distress factor is related to MDD, Dysthymic Disorder, Generalized Anxiety Disorder (GAD), and Post-Traumatic Stress Disorder (PTSD). Specific Phobias, Social Phobia, Panic Disorder, and Agoraphobia are associated with the fear dimension. Sellbom et al. (2008) extended the model using temperament markers differentiating between Demoralization, Positive Activation/Emotionality, and Negative Activation/Emotionality. These researchers used the Restructured Clinical (RC) Scales of the MMPI-2/MMPI-2-RF, which include theoretically and empirically derived measures concordant with Watson and Tellegen’s (1985) model of mood and anxiety. The best-fitting higher-order model supported a two factor distress and fear factor. Temperament markers of Demoralization were the best predictors of distress disorders whereas temperament markers of Negative Activation/Emotionality were the best predictors of fear disorders. These investigators also found, as hypothesized, that low Positive Activation/Emotionality uniquely predicts elements of MDD and Social Phobia. Overall, they demonstrated that the hierarchical structure of internalizing disorders may best be explained by three constructs labeled
Demoralization, Low Positive Emotions, and Dysfunctional Negative Emotions. This model of Internalizing Dysfunction is represented in Figure 1.1.

**1.4.2 Externalizing Dysfunction**

Krueger et al. (2002) examined the factor structure of impulse control disorders in a sample of monozygotic and dizygotic twins and concluded that variance in these disorders could be explained by an Externalizing Dysfunction construct also associated with findings on clinical interviews assessing conduct disorder, antisocial behaviors, and Alcohol/Substance Use Disorders as well as with low scores on the Constraint scale of the Multidimensional Personality Questionnaire (MPQ; Tellegen, 1993/2003). Applying behavioral genetics models to the twin data, these authors found that the externalizing dimension was associated with additive genetic heritability, whereas the residual variance (variance unique to each condition) was better accounted for by environmental factors. These findings were later replicated in a similar sample Kendler, Prescott, Myers, and Neale (2003) as well as in general population samples (Krueger et al., 2005; Krueger & Tackett, 2006) using structured interviews. Krueger et al. (2007) followed up on these findings by examining a hierarchical model of Externalizing Dysfunction.

These investigators found that the broad Externalizing factor bifactuates into two related, but distinct constructs: aggression and impulse control. This finding converges with the personality-psychopathology literature. In a meta-factor analysis, Markon, Krueger, and Watson (2005) identified dimensions similar to the Personality-Psychopathology-Five (PSY-5) constructs delineated by Harkness and McNulty (1994). Two of the dimensions identified by these authors, Aggressiveness and Disconstraint, correspond respectively to the two Externalizing Dysfunction factors just mentioned.
Notes: Adapted from the best fitting structural model reported in Sellbom, Ben-Porath, & Bagby (2008); Ovals represent psychological constructs; Rectangles represent diagnoses; Curved lines indicate correlation; Straight lines indicate causal relationships; PD (Panic Disorder); MSP (Multiple Specific Phobias); DYS (Dysthymic Disorder); GAD (Generalized Anxiety Disorder); MDD (Major Depressive Disorder); SP (Social Phobia)

*Figure 1.1:* Hierarchical Model of Internalizing Dysfunction
1.4.3 Thought Dysfunction

The higher-order Internalizing and Externalizing dimensions do not account for symptoms related to schizophrenia, delusional disorder, schizotypal and schizoid personality disorder features, and other manifestations of thought disorder. Three symptom clusters are typically associated with Schizophrenia: positive symptoms (hallucination, delusions, and bizarre and disorganized behaviors), negative symptoms (blunted affect, psychomotor retardation, and poverty of speech), and cognitive impairments (such as deficits in executive functioning, memory, visual and verbal learning, and attention) (Combs & Mueser, 2007). From a different perspective, Meehl (1962) linked thought dysfunction to a dimensional variable he labeled schizotypy. Although higher schizotypy levels are associated with increased risk for developing Schizophrenia, at lower levels individuals are at greater risk for less debilitating peculiarities of affect, thinking, and behaviors. Some symptoms and behaviors of psychotic disorders are similar to those found within the Internalizing and Externalizing spectrum. For example, negative symptoms are related to features in the dimension of low Positive Activation/Emotionality, such as affective flattening and avolition. Disorganized behaviors (such as lack of goal orientation) and persecutory delusions may predispose individuals to act out. Therefore, behavioral features often noted in individuals diagnosed with a thought disorder are similar to those found within the externalizing spectrum. However, these models do not account for positive symptoms such as hallucinations, delusions or oddities described in Meehl’s (1962) theory of schizotype.

Early on, some authors suggested primary psychotic symptoms best fit within the framework of Externalizing Dysfunction (Keshavan et al., 2008) whereas others suggested
the severe mental illness was more closely associated with Internalizing Dysfunction (Rubino et al., 2009; Verona, Sachs-Ericsson, & Joiner Jr, 2004). Still, other researchers argued that severe mental illnesses form their own, unique dimension that is independent of internalizing and Externalizing Dysfunction (Kendler & Gardner, 1997; Wolf et al., 1988). Kotov and colleagues (2011) recently explored where severe mental illnesses best fit within the higher-order structure. After replicating the Internalizing and Externalizing models, these investigators tested three models: severe mental illness as a function of Internalizing Dysfunction, severe mental illness as a function of Externalizing Dysfunction, and severe mental illness as a distinct construct. The best fitting model suggested a three-factor, higher-order model: Internalizing, Externalizing, and Thought Dysfunction (termed Schizophrenia in their study). This Thought Dysfunction construct has been replicated across other samples (Caspi et al., 2014; Kotov, Chang, et al., 2011; Markon, 2010; Wright et al., 2013).

In the psychometric assessment literature, the MMPI-2/MMPI-2-RF Restructured Clinical (RC) Scales have also been found to correspond to a three-dimensional higher order psychopathology model (Ben-Porath & Tellegen, 2008/2011; Tellegen & Ben-Porath, 2008/2011). As described by Tellegen and Ben-Porath (2008/2011), factor analyses of the RC Scales in clinical samples identified three primary sources of variance for which a set of Higher-Order Scales were developed. These scales, labeled Emotional/Internalizing Dysfunction (EID), Thought Dysfunction (THD), and Behavioral/Externalizing Dysfunction (BXD), provide validated measures of the “Big Three” psychopathology constructs reviewed in this section.
Understanding bariatric surgery outcome studies within the framework of hierarchical psychopathology models may help clarify previous inconsistent findings on associations between psychosocial risk factors and surgical results. For example, efforts to explore the role of mood and anxiety disorders in bariatric surgery outcomes, discussed earlier, have likely been hampered by the very high rates of co-morbidity among these disorders (c.f., Brown et al., 2001; Kessler et al., 2005). The consequent conceptual and measurement challenges and inconsistencies in findings can be addressed by consideration of the hierarchical models just reviewed. Initial evidence of the advantage of considering comorbidity in bariatric surgery outcomes was provided by de Zwaan and colleagues (2011). When these authors focused on preoperative depression or anxiety diagnosis, they found no association with postoperative weight loss; however, as reviewed earlier, the combination of mood and anxiety disorders was predictive of suboptimal weight loss. de Zwaan and colleagues (2011) found that patients who met criteria for both a mood and anxiety disorder (lifetime and current) prior to surgery had poorer weight loss when compared with those with no diagnoses.

1.4.4 Emotional/Internalizing Dysfunction and Bariatric Surgery Outcomes

Studies reviewed earlier, investigating the role of mood/anxiety disorders in predicting bariatric surgery outcomes are likely producing inconsistent results because the methods used to assess clinical features (e.g., structured interviews and self-report) measure different constructs. For instance, using the Beck Depression Inventory (BDI; Beck et al., 1996) as a presurgical assessment measure, some authors have reported negative associations with post-surgical weight loss (Averbukh et al., 2003) and positive associations with weight gain (Odom, 2010). On the other hand, studies using structured
interviews to derive MDD diagnoses have yielded inconsistent findings; some reporting no association with weight loss (e.g., Kalarchian et al., 2008) and others finding a positive association with this outcome (de Zwaan et al., 2011; Semanscin-Doerr et al., 2010).

Psychometrically, the BDI assesses depressive features that are more closely related to Frank’s (1974) and Tellegen (1985) construct of Demoralization. Unlike the Hamilton Rating Scale for Depression (HRSD; Hamilton, 1960), the BDI taps into more cognitive and affective domains of MDD, whereas the HRSD assesses anhedonic features of the disorder that are more congruent with low Positive Activation/Emotionality (Brown, Schulberg, & Madonia, 1995; Klein, 1974). Further, when using polythetic diagnostic criteria derived from structured interviews, one individual can meet criteria for MDD by reporting more cognitive affective symptoms of the disorder and very few, if any, vegetative symptoms outlined in the diagnostic criteria, whereas another individual diagnosed with MDD may exhibit predominantly vegetative symptoms linked to anhedonia. It is plausible that mixed findings on associations between depression and weight loss following bariatric surgery are confounded by inconsistent measurement of the construct.

Studies using the BDI to predict outcome may have found positive associations with weight loss because factors associated with Demoralization (e.g., being dissatisfied with current life circumstances) motivate patients to adhere to treatment guidelines (Ben-Porath, 2008/2011; Frank, 1974). In other words, patients who are highly distressed about their current health status or weight fluctuations after surgery may be more motivated to follow guidelines that promote weight loss maintenance. Studies using structured interviews to assess for MDD likely include individuals experiencing low levels of
positive emotions, or anhedonia. Other vegetative symptoms of depression include appetite disturbance, avolition, and loss of energy, which are associated with lack of regular exercise and poor dietary adherence (Lin et al., 2004). This, in turn, likely contributes to poorer weight loss outcome/weight regain and poor adherence to follow-up appointments. Thus, inconsistent findings on associations between depression and weight loss following bariatric surgery may well be a product of differences in the constructs assessed in those investigations.

Research on associations between anxiety-related disorders and weight loss has similarly produced inconsistent findings. Studies that have used structured interviews have typically included GAD and Social Phobia among the anxiety-related disorders (c.f., de Zwaan et al., 2011; Kalarchian et al., 2008). As discussed earlier, Watson (2005) provided the first empirical evidence that GAD does not fit well among the anxiety-related disorders and is better conceptualized as a distress disorder, which shares more features with the just-discussed construct of Demoralization. Although Social Phobia has been shown to share some features with anxiety-related disorders, this condition also includes manifestations of low Positive Activation/Emotionality (Sellbom et al., 2008). There are also concerns about the discriminant validity of self-report measures commonly used in this setting. For example, the Beck Anxiety Inventory (BAI) (Beck & Steer, 1993) is highly correlated with the BDI – II (c.f., Beck, Steer, Ball, Ranieri, 1996) and substantially correlated with a measure of Demoralization on the MMPI-2-RF in a spine surgery setting (Block, Ben-Porath, & Marek, 2013). Studies that have used the original Clinical Scales of the MMPI and the MMPI-2 are also problematic because these scales similarly lack discriminant validity (Tellegen et al., 2003). Items associated with Demoralization were
removed from the original Clinical Scales of the MMPI-2 and this construct is measured with a designated MMPI-2-RF scale. The Restructured Clinical (RC) Scales of the updated instrument better discriminate between low Positive Activation/Emotionality and high Negative Activation/Emotionality (measured as Low Positive Emotions [RC2] and Dysfunctional Negative Emotions [RC7], respectively; Tellegen et al., 2003). Other MMPI-2-RF scales provide more specific information about various specific manifestations of emotional dysfunction (e.g., Suicidal/Death Ideation, Hopelessness/Helplessness, Self-Doubt, Inefficacy, Stress and Worry, Anxiety, Anger Proneness, Behavior Restricting Fears, and Multiple Specific Fears). For example, Marek and colleagues (2013) reported results similar to those of Sellbom and researchers (2008), which demonstrated that Low Positive Emotions [RC2] was unique to the diagnosis of MDD in a sample of bariatric surgery candidates. In an outcome study, a Dysfunctional Negative Emotions [RC7] facet scale, Anxiety [AXY], was one of the strongest predictors of patients who were more likely to engage in maladaptive eating behaviors as soon as three months following bariatric surgery (Marek, Ben-Porath, Merrell, Ashton, & Heinberg, 2014). Presurgical assessment of these distinctive manifestations of emotional dysfunction may assist in pinpointing specific psychosocial risk factors for negative bariatric surgery outcomes.
1.4.5 Behavioral/Externalizing Dysfunction and Bariatric Surgery Outcomes

Measures of Loss of Control (LOC) eating, other under-controlled behaviors such as substance use, account for substantial proportions of outcome variance including poorer postoperative weight loss (Conceição et al., 2014; de Zwaan et al., 2010; Kalarchian et al., 2002), appointment non-adherence (Tarescavage et al., 2013), and maladaptive eating (Conceição et al., 2014; de Zwaan et al., 2010; Marek et al., 2014; White et al., 2010). However, challenges associated with comorbidity within the externalizing domain likely hamper research on weight loss predictors in bariatric surgery candidates as well. For example, BED is comorbid with Substance Use Disorders, but also with depression and anxiety-related disorders (Grilo et al., 2008). Although Anorexia Nervosa fits under the broad internalizing factor (Kotov et al., 2011), BED has an externalizing component, manifested in LOC. Considering the high prevalence rate for BED in bariatric surgery candidates, research integrating BED with the hierarchical models of psychopathology is needed. Moreover, there is an ongoing debate in the literature as to whether some problems associated with Externalizing dysfunction have their onset following bariatric surgery. Some candidates who struggle with impulse control in relation to food or alcohol prior to surgery may have a genetic predisposition to act impulsively in other environmental contexts. Psychopathology (Krueger et al., 2007) and personality (c.f., Markon et al., 2005 for a meta-analytic review) research implicates an individual differences construct labeled disinhibition or disconstraint as playing an important role in Impulse Control Disorders. This construct may play a similar role in LOC and AUD. Bariatric surgery candidates who are more disconstrained prior to surgery are likely at a higher risk for evidencing similar problems following surgery. Rather than focusing on a
specific behavior or disorder, research focusing on presurgical assessment of disconstraint may yield more consistent predictions of negative bariatric surgery outcomes.

In terms of other externalizing behaviors such as substance use, it has been established that a proportion (~30%) of bariatric surgery candidates minimize psychopathology, most notably impulse-control and sensation-seeking problems, during the presurgical psychological screening in order to qualify for surgery (Ambwani et al., 2013; Marek, Tarescavage, Ben-Porath, Ashton, Rish, & Heinberg, 2015; Tarescavage, Windover, et al., 2013; Walfish, 2007). Walfish (2007) administered the MMPI-2 and the BDI-II among other self-report measures of psychopathology. Bariatric surgery candidates who produced elevations on the underreporting scales of the MMPI-2 were told that the psychologist results indicated that they had either underreported on purpose or unconsciously did so. They were then asked to repeat all psychological testing. These patients evidenced no elevations on underreporting scales in the second testing session, and they scored higher across all measures administered.

In a more recent study with external criteria, (Marek et al., 2015) hypothesized that scores on MMPI-2-RF scales associated with under-controlled behaviors prior to surgery would predict suboptimal weight loss one-year following a RYGB in a sample of 339 bariatric surgery candidates. Up to 22% percent of patients evidenced some degree of under-reporting. Although the associations between presurgical scores on Behavioral/Externalizing Dysfunction and weight loss at the one-year follow-up were statistically and meaningfully significant, the magnitude of the coefficients increased after accounting for range restriction due to underreporting. These studies indicate that for some individuals’ presurgical scores on psychological tests assessing for
psychopathology, including alcohol and drug use, are likely underestimates of their level of dysfunction.

Although externalizing behaviors may have a post-surgical onset, underreporting of problem behaviors during presurgical evaluations may mask the presence or severity of disconstrained behavior. The first possibility indicates one potential advantage of conducting post-surgical assessments of bariatric surgery patients using well-validated measures of behavioral/externalizing dysfunction and the latter indicates the need to rely on presurgical measures that include scales that can assist in detecting underreporting in bariatric surgery candidates.

1.4.6 Thought/Cognitive Dysfunction and Bariatric Surgery Outcomes

Memory, attention, and executive functioning tend to improve after bariatric surgery (Gunstad, 2011). However, presurgical deficits in these domains are predictive of both poor weight loss outcomes (Spitznagel et al., 2014) and poor dietary adherence (Galioto et al., 2013). Although individuals who have thought disorder also evidence deficits in the cognitive domains outlined above, there is a dearth of literature on associations between disordered thinking and bariatric surgery outcomes. To date, only one study (2004) examined whether patients who were diagnosed with schizophrenia and treated with antipsychotic medication could achieve similar weight loss outcomes to a matched-control group. At the six month post-surgical follow-up, both groups exhibited similar weight loss outcomes.

As reviewed earlier, the higher-order construct of Though Dysfunction encompasses a broad range of odd behaviors, thoughts, and feelings described in Meehl’s (1968) theory of shizotypy. These experiences need not rise to the level of a formal
thought disorder to have a negative impact on bariatric surgery outcomes. Other related constructs are paranoia or persecutory ideation and unusual perceptions that are more closely related to Schizotypal Personality Disorder. Persecutory beliefs that are unrelated to a psychotic disorder may be the product of a lengthy history of stigmatization and discrimination in individuals with obesity (Puhl & Brownell, 2001; Wygant et al., 2007). These experiences may also be related to body image dissatisfaction due to the amount of excess skin in the abdomen, arms, legs, and thighs following rapid weight loss (Sarwer & Fabricatore, 2008). Research establishing associations between various manifestations of thought dysfunction and bariatric surgery outcomes is significantly lacking at this point.

Although deficits in executive functioning are traditionally considered to be cognitive deficits, studies have established associations between this domain and externalizing dysfunction, such as AUD (Giancola, 2004; Giancola & Moss, 1998; Parada et al., 2012) and BED (c.f., Calvo et al., 2014; Maayan et al., 2011). As reviewed earlier, deficits in executive functioning are associated with impulsivity (Moeller et al., 2001) which, in turn, is a construct related to maladaptive eating patterns (Haedt-Matt & Keel, 2011; Mobbs et al., 2010; Nederkoorn et al., 2006), including LOC. Therefore, in the structural models of Externalizing Dysfunction, measures of executive functioning will likely also load onto the disinhibition factor.

The literature reviewed in this chapter indicates how and why the current diagnostic system may be of limited utility in, and, indeed even hampering efforts to study the role of psychopathology in bariatric surgery outcomes. Building on both current psychopathology theory and bariatric surgery outcome literature, the current investigation seeks to rely on contemporary conceptual models and research methods to further the
understanding of how psychological factors relate to bariatric surgery outcomes. Studies to date point toward three higher-order constructs – Internalizing/Emotional Dysfunction, Behavioral/Externalizing Dysfunction, and Thought/Cognitive Dysfunction - that likely play a role in negative outcomes following bariatric surgery. Empirical evidence also indicates that the Internalizing/Emotional Dysfunction bifactuates into two, lower-order constructs termed Distress and Fear (Watson, 2005). A third factor, termed Low Positive Activation/Emotionality, has also been proposed (Sellbom et al., 2008).

Methodologically, Structural Equation Modeling (SEM) – a family of statistical techniques for testing correlational and longitudinal models – may assist in studying associations between psychopathology and bariatric surgery outcomes. Kline (2010) and Little (2013) detail a number of pertinent strengths of this approach. For instance, latent growth curve modeling (a specific SEM application) can be used to build and test a number of longitudinal prediction models (e.g., linear, non-linear, piecewise, etc.) of bariatric surgery outcomes. Figure 1.1 (discussed earlier) depicts an example of how a SEM framework can accommodate previously reported findings based on the DSM diagnostic nosology in a model that accounts for comorbidity based on the contemporary hierarchical models of psychopathology reviewed in this paper. Another advantage of SEM is the ability to consolidate reliable, shared variance across multiple measures (i.e., diagnoses, self-report, and other sources from medical record reviews) while controlling for measurement error. Longitudinal SEM models that include pre- and post-surgical assessment of psychopathology can test whether the constructs assessed at the presurgical evaluation are reliably and consistently measured across time and whether difference in
the rate of weight loss varies across times owing to psychopathology. The following three hypotheses will be tested:

1.5 Hypothesis 1: Mapping Pre-surgical Psychological Variables onto the Hierarchical Psychopathology Models Will Clarify Previous Inconsistent Findings on Associations between Psychosocial Risk Factors and Surgical Weight Loss Results.

Hierarchical models of psychopathology will be tested using a large sample of bariatric surgery candidates that obtained a RYGB. Specifically, the models will be structured using indicators across multiple methods of the psychological evaluation process. The following data will be used: psychological diagnoses derived from a semi-structured interview, medical chart review information, MMPI-2-RF scores, and scores from a rating form of clinicians’ concerns about patients. It is hypothesized that the indicators will converge on two latent constructs consistent with previous literature across other samples: Internalizing and Externalizing Dysfunction (Figure 1.2). Although the literature also supports the presence of a third higher-order construct – Thought Dysfunction –, this construct will not be modeled in the current investigation because: 1) there were not enough unique indicators for the construct in the current sample, and, relatedly, 2) the base rate for thought disorders and associated symptoms for patients who obtained surgery tend to be low (Marek et al., 2013; Mitchell et al., 2012). The two-factor Internalizing Dysfunction and Externalizing Dysfunction model will be contrasted with the model proposed by Watson (2005). It is hypothesized that the broad Internalizing Dysfunction dimension will be better captured by two lower-order constructs: Demoralization and High Negative Activation/Emotionality (Figure 1.3).
Note: sub (Substance Use Disorder); cra (Clinician Rating of Adherence); rc4 (Antisocial Behaviors); sav (Social Avoidance); pd (Panic Disorder); brf (Behavior Restricting Fears); axy (Anxiety); rc2 (Low Positive Emotions); sui (History of Suicidal Attempts); gad (Generalizing Anxiety Disorder); red (Demoralization)

Figure 1.2: Hypothesized Internalizing/Externalizing Hierarchical Model of Psychopathology
Note: sub (Substance Use Disorder); cra (Clinician Rating of Adherence); rc4 (Antisocial Behaviors); sav (Social Avoidance); pd (Panic Disorder); brf (Behavior Restricting Fears); axy (Anxiety); rc2 (Low Positive Emotions); sui (History of Suicidal Attempts); gad (Generalizing Anxiety Disorder); rcd (Demoralization)

Figure 1.3: Hypothesized 3-Factor Hierarchical Model of Psychopathology
Lastly, Sellbom et al. (2008) extended research by Watson (2005) by providing empirical evidence that Major Depressive Disorder and Social Phobia were uniquely associated with a measure of Low Positive Activation/Emotionality. Therefore, a model with three lower-order constructs of the Internalizing Dysfunction domain (Demoralization, Negative Activation/Emotionality, and Low Positive Activation/Emotionality) will be tested and compared to the more parsimonious models above. It is hypothesized that the three lower-order construct model of Internalizing Dysfunction domain will fit significantly better than models described above (Figure 1.4).

1.6 Hypothesis 2: Nonlinear Latent Growth Curves Will Better Explain Weight Loss Variability Across Time than Do Linear Models.

Weight loss after bariatric surgery is not linear (Magro et al., 2008; Mechanick et al., 2013; O'Brien et al., 2004; Odom et al., 2010; Sjostrom et al., 2007). Specifically, there are drastic changes in weight from the time of surgery until twelve to eighteen months post-surgery. From that point forward, weight loss begins to slow, and a majority of patients begin to either plateau or evidence weight regain (range: 15%-50%; Magro et al., 2008; Mechanick et al., 2013; O'Brien et al., 2004; Odom et al., 2010; Sjostrom et al., 2007). However, many studies have used statistical methods that assume linearity, such as ordinary least squares regression, deriving change scores, Pearson Product-Moment Correlations, and repeated- or mixed-ANOVAs.

In addition, previous research that relied on these traditional, linear methods were under-powered, reported unreliable coefficient estimates due to artificially dichotomizing variables, modeled measurement error, and rarely accounted for missing data. Moreover,
Note: sub (Substance Use Disorder); cra (Clinician Rating of Adherence); rc4 (Antisocial Behaviors); sav (Social Avoidance); pd (Panic Disorder); brf (Behavior Restricting Fears); axy (Anxiety); rc2 (Low Positive Emotions); sui (History of Suicidal Attempts); gad (Generalizing Anxiety Disorder); red (Demoralization)

Figure 1.4: Hypothesized 4-Factor Hierarchical Model of Psychopathology
traditional techniques are useful for modeling group level trends, but they do not convey information about individual level tendencies (i.e., do rates of change across time differ significantly between individuals).

A contemporary and flexible technique that addresses the limitations outlined above relies on latent growth curve models (Ducan, Ducan, Strycker, Li, & Alpert, 1999). These models offer a number advantages over traditional techniques of modeling change across time. For instance, they can model nonlinear trends and whether individuals’ growth rates differ (i.e., do individuals who are ‘super obese’ lose weight faster or slower than individuals who are not as obese?). Latent growth curve modeling can also control for measurement error and handle missing data across time. Moreover, the intercept in the models can be moved throughout the trajectory to answer additional hypotheses about change over time. For example, it is expected that bariatric surgery patients will lose a substantial amount of weight from their surgery date to the one-year outcome. Having the intercept at the first time point would reflect individual differences in BMI at the time of their evaluation. The intercept can be moved to a later time point (i.e., five-year postsurgical time point) to reflect individual differences at the end of the trajectory (i.e., does pre-surgical psychopathology predict higher BMIs at the 5-year follow-up?). Lastly, latent growth curves model variability around the slope and intercept. Predictor variables can then be used to test whether they account for variability around the intercept and the slope. For example, it is possible that patients who evidenced pre-surgical psychopathology demonstrate a slower rate of change compared to individuals whose psychosocial functioning was normal at the pre-surgical evaluation.
The current investigation seeks to build a growth trajectory for weight loss five years after a RYGB. Based on previously published weight loss studies that have used means and standard deviations of bariatric surgery outcomes to plot trajectories (Magro et al., 2008; Mechanick et al., 2013; O'Brien et al., 2004; Odom et al., 2010; Sjostrom et al., 2007), it is hypothesized that the weight loss trend after bariatric surgery will be non-linear. Specifically, a linear model (Figure 1.5) will be tested against a non-linear model (Figure 1.6). In the linear model, a latent intercept and slope will be derived from BMIs at the following time points: Intake, 3-months post-surgery, 6-months post-surgery, one-year post-surgery, five-years post-surgery. The intercept will also be placed at the five-years post-surgery to reflect individual differences five years after bariatric surgery (i.e., who is regaining weight vs. who is plateauing/losing weight) in some prediction models. The linear model will be tested against a non-linear model (unconditional model) in which a latent intercept and latent slope will be derived based a combination of linear and curvilinear trends that the software deems appropriate. A non-linear curve fitting procedure allows the factor loadings on the slope to be freely estimated (i.e., have the program estimate a growth curve based on the data). In other words, an exploratory procedure seeks to identify an optimally fit latent slope factor for the data. The best fitting model will then be tested against both a quadratic model (Figure 1.7) and a piecewise model (Figure 1.8).
Note: I (BMI Differences where the Factor Loading for the Slope is equal to 0); S (Slope – Rate of BMI-Reduction Across Time); Straight lines indicate paths whereas curved lines indicate correlations. Circles represent latent measures whereas squared boxes represent observed variables; Numerical whole numbers represent unstandardized factor loadings

*Figure 1.5:* Linear Growth Model
Note: I (BMI Differences where the Factor Loading for the Slope is equal to 0); S (Slope – Rate of BMI-Reduction Across Time); Straight lines indicate paths whereas curved lines indicate correlations. Circles represent latent measures whereas squared boxes represent observed variables; Numerical whole numbers represent unstandardized factor loadings.

*Figure 1.6: Non-Linear Growth Model*
Note: I (BMI Differences where the Factor Loading for the Slope is equal to 0); S (Slope – Average Rate of BMI-Reduction Across Time); Q (Average Rate of Departure from Linearity Over Time); Straight lines indicate paths whereas curved lines indicate correlations. Circles represent latent measures whereas squared boxes represent observed variables; Numerical whole numbers represent unstandardized factor loadings

Figure 1.7: Quadratic Growth Model
Note: I (BMI Differences where the Factor Loading for the Slope is equal to 0); S1 (Slope – Average Rate of BMI-Reduction Across Time from Baseline to 6-month post-surgery); S2 (Slope – Average Rate of BMI-Reduction Across Time from 6-month post-surgery to 5-years post-surgery); Straight lines indicate paths whereas curved lines indicate correlations. Circles represent latent measures whereas squared boxes represent observed variables; Numerical whole numbers represent unstandardized factor loadings.

*Figure 1.8:* Piecewise Growth Model
A quadratic model will test for curvilinear changes across time, such that weight loss will be linear and then begin to increase over time. In a piecewise model, the first slope will predict the rate of change from intake to 6-months post-surgery that will reflect the rapid weight loss from RYGB. The second slope will be reflective of the rate of change from one to five years post-, when the surgical effects begin to wear off and during which weight plateauing and regain tend to occur.

1.7 Hypothesis 3: Pre-surgical Psychopathology as Assessed with Measures of Contemporary Hierarchical Models, Will Predict Slower Rates of Change in BMI Across Time and Will Be Associated with Higher % BMI at the 5-year Outcome.

Many of the studies reviewed earlier suggest that pre-surgical psychopathology is related to poorer weight loss across time (c.f., de Zwaan et al., 2011, Green et al., 2004; Semanscin-Doerr et al., 2010; White et al., 2010). Using the best fitting models derived from testing the first two hypotheses, it is postulated that pre-surgical psychopathology as assessed with measures of contemporary hierarchical models will predict variability in BMI at the 5-year outcome. Specifically, it is hypothesized that pre-surgical psychopathology will be positively associated with BMI at the 5-year outcomes after controlling for age, such that it will predict higher BMIs at the 5-year period. Age will be used as as a covariate due to its previous associations with weight loss in the current sample and other samples (c.f., Marek et al., 2015; Sugerman et al., 2004). Moreover, it is hypothesized that patients with slower rates of change in BMI-reduction across time will also have higher levels of pre-surgical psychopathology.
CHAPTER 2

METHOD

2.1 Participants

The study targeted 451 consecutively consented patients who underwent RYGB at least 5-years prior. The 451 patients chosen for inclusion in the study resided in Northeast Ohio because if the patient presented at Cleveland Clinic Main Campus or any of the associated satellite campuses, their weight were accessible from their electronic medical records. Of these individuals, 5 produced an invalid MMPI-2-RF protocol based on guidelines outlined in the MMPI-2-RF Technical Manual (Tellegen/Ben-Porath, 2008/2011): Cannot Say [CNS] ≥ 18, Variable Response Inconsistency [VRIN-r] ≥ 80, True Response Inconsistency [TRIN-r] ≥ 80, Infrequent Responses [F-r] ≥ 120, & Infrequent Psychopathology Responses [Fp-r] ≥ 100. These 5 participants were excluded from further analyses because these response styles also distort other assessments of psychopathology (Crighton, Tarescavage, Gervais, & Ben-Porath, 2015; Forbey et al., 2013). There were no statistically significant differences on demographic or psychological variables between those who produced valid or invalid protocols. Of the 446 participants retained for analyses, 74.2% were women. Ethnic breakdown was 66.2% Caucasian, 19.7% African American, and 14.1% of another ethnicity. The mean age of the cohort was 46.75 years (SD = 11.63; Range 18 – 74). Patients’ mean pre-surgical BMI was 49.14 kg/m² (SD = 9.50 kg/m²). Importantly, 38.1% of the sample engaged in
an under-reporting response style on the MMPI-2-RF [Uncommon Virtues (L-r) ≥ 65T or Adjustment Validity (K-r) ≥ 60T], though for a portion of these individuals, their scores may also reflect traditional upbringing or being psychologically well-adjusted. Of those who met these criteria, 33% scored at or above the highest recommended interpretative T-Score cut-offs on these scales [Uncommon Virtues (L-r) ≥ 80T or Adjustment Validity (K-r) ≥ 70T].

2.2 Measures

2.2.1 Semi-Structured Psycho-Diagnostic Interview.

A semi-structured interview that is mandated by the Cleveland Clinic was administered by a doctoral level psychologist or a post-doctoral fellow under their supervision. Information obtained during the interview included: an evaluation of DSM-IV-TR diagnoses and a history and current mental health issues, such as history of past suicide attempts, and a history or current use of alcohol or other illicit substances. Although reliability data (e.g., inter-rater reliability) are not available, information obtained from the semi-structured psycho-diagnostic demonstrate good convergent and discriminant validity with psychopathology self-report measures (Marek et al., 2013). These data were coded through a retrospective chart review by trained research assistants. Data were then double entered to maintain consistency and reduce typographical error. Inter-rater reliability (Kappa statistics) between coders was .96 (Range = .81-1.00). This process as well as inter-rater reliability coefficients have been reported in the literature (Marek et al., 2013).
2.2.2 Minnesota Multiphasic Personality Inventory – 2 – Restructured Form (MMPI-2-RF; Ben-Porath & Tellegen, 2008/2011; Tellegen & Ben-Porath, 2008/2011).

The MMPI-2-RF consists of 338 true-false items that are scored on 9 scales of protocol validity and 42 substantive scales of psychological constructs. The substantive scales of the test are organized similar to contemporary hierarchical models of psychopathology that assess emotional, behavioral, and thought dysfunction (Kotov, Ruggero, et al., 2011; Krueger & Markon, 2006; Sellbom et al., 2008), in addition to various somatic/cognitive complaints and interpersonal problems. The MMPI-2-RF contains the Personality Psychopathology – 5 (PSY-5) scales that are conceptually similar to the hybrid-trait model of personality disorders outlined in Section III of the DSM-5 (Anderson et al., 2013). Finally, MMPI-2-RF scale scores have good estimated reliabilities, good convergent discriminant validity, replicated normative data, associations with outcomes including weight loss, adherence, and somatic, psychological, and eating behavior criteria, they are not demographically biased by gender, ethnicity, or age groups when used in bariatric surgery settings (Marek, Ben-Porath, Sellbom, McNulty, & Heinberg, 2014; Marek et al., 2013; Tarescavage et al., 2013). Raw scores will be used in all analyses.

2.2.3 Cleveland Clinic Behavioral Rating Scale (CCBRS; Heinberg, Ashton, & Windover, 2010).

The CCBRS contains 8-items that assess various domains of consideration for bariatric surgery. Each domain is scored on a 5-point likert scale; such that higher numbers indicate a more positive outlook based on clinician judgment. The instrument
yields good inter-rater reliability (Kappa = .82), good internal consistency (r = .88), and predicts weight loss outcomes in this population (Heinberg, Ashton, & Windover, 2010). The “Adherence” domain was used in subsequent analyses.

2.3 Procedure

A graduate student and an undergraduate student trained to achieve good consistency with the graduate student, coded information from each patient’s pre-operative, semi-structured psychiatric interview. Coded data included medical chart information and diagnoses that were gathered by a doctoral level clinical psychologist at the time of the intake. The clinical psychologists review information with each patient in a structured, template manner as part of a standardized electronic medical record. Thus, every patient is evaluated on the following criteria during the psychiatric evaluation with the clinical psychologist: past mental health history/treatment, current mental health diagnoses/treatment, past and current substance use/abuse/dependence, physical and sexual abuse history, and history of past suicide attempts. BMI was taken from the electronic medical record at the time of their evaluation, whereas post-operative BMIs were gathered within a 1-month range of the post-operative time point.

2.4 Data Analysis

All analyses were computed in Mplus 7.3 (Muthén & Muthén, 1998-2012). Means and standard deviations were calculated for continuous variables and base rates were calculated for dichotomous variables. Pearson Product-Moment Correlations were calculated between continuous variables whereas point-biserial correlations were calculated when using a dichotomous variable in the equation. Correlations were interpreted based on effect size guidelines for behavioral medicine research: >.20 was a
small effect, .20 - .30 was a medium effect, and <.30 was a large effect (Hemphill, 2003). Confirmatory Factor Analyses (CFAs) were conducted to create latent variables to test the hierarchical models of psychopathology at the pre-surgical time point. For the five BMI variables across time, latent growth curve analyses were estimated. Because the latent intercept depicted in Figures 1.5-1.8 are analogous to the intercept in a regression equation, the unstandardized factor loadings will be fixed at 1. In some analyses, the intercept will be centered at the five-year, post-surgical time point in some models to evaluate whether higher levels of pre-surgical psychopathology predict higher BMIs at the five-year, post-surgical time point. The slope will be estimated based on time intervals between weight assessments. In Figures 1.5-1.8, a ‘0’ references where the intercept is being estimated. A ‘0’ fixed to the first time point assesses BMI differences at intake whereas a ‘0’ at the last time point references BMI differences at the 5-year post-surgical time point. Unstandardized factor loadings were spaced based on how much time elapsed from the intercept to the adjacent time point. For example, Figure 1.5 depicts a model with the intercept centered when BMI was assessed during intake. The second time point (3-month post-surgical BMI) yields a value of ‘1’, suggesting that each consecutive time point reflects a change in BMI across a span of 3-months. The unstandardized loading for the 6-month BMI observed variable will therefore be set to ‘2’.

For CFA analyses reported in section 3.2, a robust weighted least squares estimator (WLMSV) was used to compute models because it better handles data that contain a large number of indicators that are dichotomous (Flora & Curran, 2004). Non-significant Chi-Square statistics indicate good model fit, but are influenced by sample
size (Kline, 2010). Therefore, the following goodness-of-fit indexes were used to evaluate the adequacy of the models tested: the Root Mean Square Error of Approximation (RMSEA; Browne & Cudeck, 1993) and the Comparative Fit Index (CFI; Bentler, 1990). RMSEA values of .05, .08, and .10 are considered excellent, good, and poor fit, respectively whereas values ≥ .90 for the CFI are considered indicators of good model fit (Hu & Bentler, 1999). Models were compared using the DIFFTEST option in Mplus. Model comparisons are written such that a statistically significant Chi-Square statistic indicated the more complex model fit the data better than a more parsimonious one.

For estimation of the latent growth curve models reported in Section 3.3, Robust Maximum Likelihood was used to estimate models because some variables included in analyses presented in Section 3.4 were not normally distributed. Full Information Maximum Likelihood (FIML) was used to handle data missing across time. In addition to using the guidelines mentioned earlier to compare model fit (RMSEA & CFI), the Bayesian Information Criterion (BIC; Schwarz, 1978) was also be used. The BIC is not standarized. Therefore, the BIC could only be used as a comparative fit index, with smaller values indicating better model fit when compared to a model with larger BIC statistic. Additionally, Satorra-Bentler Scaled Chi Square Difference testing (Satorra, 2000) was also used to compare models, with a statistically significant chi-square value indicating that the more complex model fits the data better than a less restrictive one.

The models described in Section 3.4 contain the best fitting models from Section 3.2 and 3.3 (considered the baseline model). These models were also estimated using a Robust Maximum Likelihood estimator because although the indicators for the dependent
variables (the Intercepts and the Slope) were derived from continuous variables, other variables in the model were either positively skewed (e.g., MMPI-2-RF scales) or were categorical (e.g., presence or absence of a diagnosis). FIML was used to handle missing data across time. Although the latent intercepts and slope were estimated using continuous variables, many of the pre-surgical psychological constructs had dichotomous indicators. Therefore, it was not possible to estimate model fit statistics, such as RMSEA and CFA because Maximum-Likelihood estimations with dichotomous variables because their insufficient statistics to estimate usual model test of fit (Muthen & Muthen, 2014). Instead, chi-square values based on log-likelihood ratios were used to compare incremental fit of the models, such that a non-significant chi-square statistic indicated that the more complex model (a model that suggests pre-surgical psychopathology predicts outcomes) did not provide better fit statistics than the baseline model (the model where no path coefficients are specified; Yuan & Bentler, 2000). Akaike’s Information Criteria (AIC; Akaike, 1978) and BIC were also used to compare models. Models with smaller values indicated better model fit when compared to a model with larger AIC or BIC statistics.

2.4 Statistical Power Analysis

A statistical power analysis was conducted to determine the a priori sample size needed to yield meaningful results and reduce the risk of making a Type II Error. The method used to conduct the power analysis is outlined by MacCallum, Browne, and Sugawara (1996). The null model has 190 degrees of freedom. The number of specified paths and constructs will take up 67 degrees of freedom. Therefore, the model was calculated to have 127 degrees of freedom. Power was set at .80 and an alpha was set at
.05. The null RMSEA was set to .05 and the alternative RMSEA was set to .08. The minimum sample size needed for the structural model structure and to find statistically significant effect assuming medium effect sizes is 173.
CHAPTER 3

RESULTS

3.1 Descriptive Statistics and Correlational Analyses

First, descriptive statistics and zero-order correlations were computed for the variables used in subsequent analyses. Table 1 contains correlations between all variables used in the current investigation. The lower portion of Table 1 contains means and standard deviations for continuous variables, base-rates for categorical variables, and percent missing for all variables used in the subsequent analyses.

Turning first to the upper portion of Table 1, patients’ age was positively associated with scores on MMPI-2-RF Scales Demoralization and Low Positive Emotions (small effect sizes). As expected, all MMPI-2-RF scales were positively associated with each other to some degree. The diagnosis of Generalized Anxiety Disorder was correlated with higher scores on MMPI-2-RF scale Demoralization, Major Depressive Disorder, 6-month Post-Surgical BMI. Major Depressive Disorder was also positively associated with the Malaise and Anxiety scales of the MMPI-2-RF, though the effect sizes were small. A history of Substance Use Disorder was negatively associated with the Clinician Rating of Adherence (medium effect size) and positively associated with the Antisocial Behaviors and Behavior Restricting Fears scales of the MMPI-2-RF (small effect sizes). All MMPI-2-RF scales except for Low Positive Emotions were associated with a history of suicide attempts (small to medium effect sizes). Moreover, a history of suicide attempts was negatively associated with the Clinician Rating of
Table 1. Descriptive Statistics and Correlations between All Variables

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<th>Low Positive Emotions</th>
<th>Antisocial Behavior</th>
<th>Anxiety</th>
<th>Behavior-Restricting Fears</th>
<th>Social Avoidance</th>
<th>GAD</th>
<th>MDD</th>
<th>Panic Disorder</th>
<th>Substance Use Disorder</th>
<th>History of Suicide Attempts</th>
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Note: ** p < .05; *** p < .001; BMI (Body Mass Index); GAD (Generalized Anxiety Disorder); MDD (Major Depressive Disorder)
Note: ** p < .05; *** p < .001; BMI (Body Mass Index); GAD (Generalized Anxiety Disorder); MDD (Major Depressive Disorder)

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Note: ** p < .05; *** p < .001; BMI (Body Mass Index); GAD (Generalized Anxiety Disorder); MDD (Major Depressive Disorder);
Adherence (small effect size). Lower Clinician Ratings of Adherence were negatively correlated with all MMPI-2-RF scales except Low Positive Emotions (small effect sizes).

Turning to the lower portion of Table 1, mean scores of the MMPI-2-RF scales were lower than those typically produced by bariatric surgery samples. Similarly, prevalence of psychiatric diagnoses was also much lower than typically observed in this population. The prevalence of past suicide attempts in this sample was also lower than expected compared to the prevalence statistics typically reported in the literature. BMI means and standard deviations across time was similar to weight loss outcomes reported in other longitudinal RYGB studies. Correlations between demographic or psychological variables and attrition over time suggest that younger individuals evidence higher amounts of missing data over time \( r = -.18 \). No other statistically significant correlation coefficients were observed between demographic or psychological variables and attrition over time.

3.2 Mapping Pre-surgical Psychological Variables onto the Hierarchical Psychopathology Models

CFAs were utilized both to test whether the psychological variables adhere to the hierarchical structure of psychopathology models reported in the literature, and to extend these findings by testing the uniqueness of a Low Positive Activation/Emotionality factor within the Internalizing Dysfunction domain. All standardized factor loadings and correlations between factors for all of the CFAs are depicted in Figures 3.1 – 3.5. A broad two factor Internalizing/Externalizing Dysfunction factor structure (Figure 3.1) was
Figure 3.1: Two-Factor Internalizing/Externalizing Factor Loadings and Correlations
Note: ext (Externalizing); hne (High Negative Activation/Emotionality); (Substance Use Disorder); cra (Clinician Rating of Adherence); rc4 (Antisocial Behaviors); sav (Social Avoidance); pd (Panic Disorder); brf (Behavior Restricting Fears); axy (Anxiety); rc2 (Low Positive Emotions); sui (History of Suicidal Attempts); gad (Generalizing Anxiety Disorder); rcd (Demoralization)

Figure 3.2: Three-Factor Internalizing/Externalizing Factor Loadings and Correlation
Figure 3.3: Four-Factor Internalizing/Externalizing Factor Loadings and Correlations
Figure 3.4: Four-Factor Higher-Order Internalizing/Externalizing Factor Loadings and Correlations
Figure 3.5: Three-Factor Higher-Order Internalizing/Externalizing Factor Loadings and Correlations
tested first and model fit indices yielded mix support for a two-factor structure \( \chi^2(53) = 131.33, p < .001, \text{RMSEA} = .058, \text{CFI} = .87 \).

Next, a three factor structure (Figure 3.2) was tested and compared against the two factor structure. The three-factor structure consisted of an Externalizing Dysfunction and two Internalizing Dysfunction factors, labeled Demoralization and High Negative Activation/Emotionality. Model fit for the three-factor model also yielded mixed support \( \chi^2(51) = 129.00, p < .001, \text{RMSEA} = .059, \text{CFI} = .87 \), though it indeed fit statistically better than the two-factor model \( \Delta \chi^2(2) = 14.63, p < .001 \). The hypothesized four-factor model was tested next. The four-factor model specified an Externalizing Dysfunction factor and three constructs related to mood and anxiety: Demoralization, High Negative Activation/Emotionality, and Low Positive Activation/Emotionality. Model fit for the four-factor structure (Figure 3.3) yielded good to excellent fit indices \( \chi^2(48) = 83.53, p = .001, \text{RMSEA} = .041, \text{CFI} = .94 \). Moreover, the hypothesized four factor model fit statistically better than the two-factor \( \Delta \chi^2(5) = 70.42, p < .001 \) and the three-factor model \( \Delta \chi^2(3) = 60.09, p < .001 \).

Hierarchical CFAs were modeled next to test whether inclusion of a lower-order Low Positive Activation/Emotionality fit as well as or better than the hierarchical Internalizing Dysfunction psychopathology structures outlined in the literature (c.f. Krueger & Markon, 2006; Watson, 2005). The first model tested for a higher-order Internalizing Dysfunction construct which had the lower-order Demoralization, High Negative Activation/Emotionality, and Low Positive Activation/Emotionality constructs loading onto the higher-order factor (Figure 3.4). Model fit was good for the hypothesized hierarchical model \( \chi^2(48) = 84.52, p = .002, \text{RMSEA} = .039, \text{CFI} = .94 \).
and provided incremental fit $[\Delta \chi^2(3) = 60.09, p < .001]$ over the hierarchical models typically structured in the literature (Figure 3.5), which only provided poor to adequate fit $[\chi^2(48) = 120.77, p < .001, \text{RMSEA} = .055, \text{CFI} = .88]$.

3.3 **Nonlinear BMI-Reduction Models Better Explain Weight Loss Variability Over Time**

The next set of analyses sought to test the hypothesis that non-linear growth models best captured weight loss trajectories following bariatric surgery. Age was included in the covariance matrix because of its relationship with missing data over time. The first longitudinal model (Figure 3.1) tested the appropriateness of a linear model (i.e., weight loss was a continuous, negative linear trajectory). As expected, a linear fit to the data yielded poor fit statistics $[\chi^2(15) = 265.76, p < .001, \text{RMSEA} = .194, \text{CFI} = .03, \text{BIC} = 15027.476]$, indicating that a linear model does not adequately capture how weight loss changes over 5-years following bariatric surgery. Next, non-linear model was specified by freeing the factor loadings from the 6-month BMI time point to the 5-year BMI time point. A non-linear model fit the data significantly better than a linear model [Satorra-Bentler Scaled $\chi^2(3) = 73.61, p < .001, \Delta \text{BIC} = 1264.95$]; however, fit statistics still indicated poor fit $[\chi^2(12) = 56.01, p < .001, \text{RMSEA} = .091, \text{CFI} = .83, \text{BIC} = 13762.52]$. A quadratic model $[\chi^2(12) = 325.55, p < .001, \text{RMSEA} = .242, \text{CFI} < .01, \text{BIC} = 14266.81$ did not adequately converge because the latent variable covariance matrix was not positive definite. An examine of the model suggested that the Quadratic factor had a non-significant variance value associated with it (Residual Variance = -.009, $p = .939$), inferencing that adding Quadratic factor likely not the best fit for the data.
A piecewise model did not appropriately converge because the standard errors of the model could not be calculated by the statistical program, likely because the piecewise model was too complex for the number of indicators included in the model. Therefore, the non-linear model was retained for further analyses.

Because the non-linear model only approached adequate fit, an examine of modification indices were examined. Modification indices suggested that homoscedasticity of error variances should not be assumed. Error variances between month-3 BMI and the 6-month and 12-month BMI were suggested to be correlated. Moreover, the error variances between the 12-month BMI and the 5-year BMI were suggested to be correlated. Specifying these correlations incrementally improved model fit for the non-linear model when comparing it to a model that assumed equal error variances [Satorra-Bentler Scaled $\chi^2(3) = 23.74, p < .001, \Delta\text{BIC} = 55.64$] and the overall model fit was acceptable [$\chi^2(9) = 19.15, p = .024, \text{RMSEA} = .050, \text{CFI} = .96, \text{BIC} = 13706.88$]

The non-linear model was then estimated using age as a predictor of BMI-Reduction over time. This would demonstrate that BMI-Reduction following bariatric surgery is better modeled as a function of age. Indeed, model fit improved [$\chi^2(7) = 12.36, p = .089, \text{RMSEA} = .041, \text{CFI} = .98, \text{BIC} = 10245.35$] and demonstrated an incremental fit for the data [Satorra-Bentler Scaled $\chi^2(2) = 7.48, p = .024, \Delta\text{BIC} = 3,461.53$]. A graphical representation using observed means is provided in Figure 3.6.
Figure 3.6: Observed BMIs Across Time as a Function of Age
Overall, the model (after controlling for measurement error and missing data) estimated
patients’ BMIs were approximately 49.15 kg/m² at the time of the pre-surgical evaluation
and by the 5-year outcome, most patients’ BMIs were approximately 35.12 kg/m²;
however, variance around those estimates was both statistically significant, indicating
considerable variability in patients’ BMIs both at the time of the evaluation and at the 5-
year post-operative time point. The mean of the slope was negative (-10.40 kg/m²)
indicating that most patients can expect a reduction of 10.40 kg/m² of their BMI over the
5-year time span. Unlike the intercepts, the variance around the slope was not statistically
significant, indicating that most individuals followed a similar BMI reduction trajectory,
likely due to the correlation between the intercept and the slope. The correlation between
the intercept and the slope revealed that an association between pre-surgical BMI and the
rate of BMI-Reduction was statistically significant, indicating that patients with higher
starting BMIs evidenced a faster rate of change than patients with lower starting BMIs.

Because the best fitting BMI-reduction model specified is one that optimally fits a
trajectory with linear and curvilinear trends, examination of the unstandardized factor
loadings is needed to depict it. The latent means across time were similar to the observed
means reported in Table 1 and Figure 3.6: Presurgical BMI = 49.15 49.15 kg/m², 3-
Month Post-Surgical BMI = 38.75 kg/m², 6-Month Post-Surgical BMI 35.32 kg/m², One-
Year Post-Surgical BMI = 32.61 kg/m², and Five-Years Post-Surgical BMI = 35.11
kg/m². Taken together, a BMI reduction trajectory that best fits the data is one that
models weight loss in a decreasing linear trend up to one-year post-surgery, and then a
slightly increasing linear trend from the one-year post-surgical follow-up to the five-year
post-surgical outcome. The parameter estimates are depicted in Figure 3.7. Factor
loadings are reported as unstandardized coefficients whereas the correlation and path coefficients are standardized. The negative association between the intercept and the slope ($r = -.70$) indicates that individuals with a higher BMI at the time of the evaluation evidenced a faster rate of BMI reduction over time than individuals whose BMIs were not as high at the time of the evaluation. This trend is controlled for in all subsequent analyses. Moreover, patients’ age yielded a statistically significant path coefficient to the intercept, indicating that younger individuals had statistically higher weights at the pre-surgical evaluation than did older patients in this sample ($\beta = -.10, p = .049$), though there were no differences in age and BMI by the five-year outcome ($\beta = -.01, p = .807$). However, BMI reduction across time varied as a function of age, such that older adults tended to have a slower rate of BMI reduction across time than did younger adults ($\beta = .35, p < .001$). This model will be used as the baseline model of BMI reduction across time in subsequent analyses.

### 3.4 Incremental Contribution of Psychopathology in Predicting BMI Reduction

The final set of analyses sought to test the hypothesis that pre-surgical psychopathology as measured by variables adhering to modern psychopathology models predicts BMI-reduction 5-years after bariatric surgery while controlling for age. These analyses also tested whether psychopathology can predict differences in the rate of BMI-change across time. Using the non-linear BMI-Reduction model that included age as a covariate (see section 3.3 for model results and Figure 3.7 for a depiction), the beginning and ending intercept and the slope was regressed onto each of the pre-surgical psychological constructs. Model fit statistics for all of the models are reported in Table 2.
Correlation and Path Coefficients Are Standardized; I (BMI Differences where the Factor Loading for the Slope is equal to 0); S (Slope – Average Rate of BMI-Reduction Across Time); Straight lines indicate paths whereas curved lines indicate correlations. Circles represent latent measures whereas squared boxes represent observed variables; Numerical whole numbers represent unstandardized factor loadings whereas decimal values represent beta weights

*Figure 3.7* Non-Linear BMI-Reduction Model as a Function of Age

Note: *p<.05; **p<.01;
Table 2. *Model Fit Statistics of Pre-Surgical Psychopathology Predicting 5-Year Post-Surgical BMIs and BMIs and BMI-Reduction*

Note: Bold indicates incremental model fit in relation to the baseline model;

<table>
<thead>
<tr>
<th>Model</th>
<th>AIC</th>
<th>BIC</th>
<th>Log Likelihood Ratio</th>
<th>$\chi^2$ (df)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline BMI-Reduction Model</td>
<td>22523.60</td>
<td>22753.22</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Externalizing Dysfunction Predicting Initial BMI and Slope.</td>
<td>22521.68</td>
<td>22759.50</td>
<td>5.71 (2)</td>
<td>.058</td>
<td></td>
</tr>
<tr>
<td><strong>Externalizing Dysfunction Predicting 5-Year BMI</strong></td>
<td><strong>22520.00</strong></td>
<td><strong>22753.72</strong></td>
<td><strong>4.06 (1)</strong></td>
<td><strong>.044</strong></td>
<td></td>
</tr>
<tr>
<td>Low Positive Activation/Emotionality Predicting Initial BMI and Slope.</td>
<td>22524.92</td>
<td>22762.74</td>
<td>2.03 (2)</td>
<td>.362</td>
<td></td>
</tr>
<tr>
<td>Low Positive Activation/Emotionality Predicting 5-Year BMI</td>
<td>22523.24</td>
<td>22756.96</td>
<td>1.43 (1)</td>
<td>.232</td>
<td></td>
</tr>
<tr>
<td>High Negative Activation/Emotionality Predicting Initial BMI and Slope.</td>
<td>22524.72</td>
<td>22762.54</td>
<td>1.93 (2)</td>
<td>.380</td>
<td></td>
</tr>
<tr>
<td>High Negative Activation/Emotionality Predicting 5-Year BMI</td>
<td>22523.44</td>
<td>22757.16</td>
<td>.97 (1)</td>
<td>.325</td>
<td></td>
</tr>
<tr>
<td>Demoralization Predicting Initial BMI and Slope</td>
<td>22526.09</td>
<td>22763.91</td>
<td>1.16 (2)</td>
<td>.559</td>
<td></td>
</tr>
<tr>
<td>Demoralization Predicting 5-Year BMI</td>
<td>22524.79</td>
<td>22758.51</td>
<td>.31 (1)</td>
<td>.578</td>
<td></td>
</tr>
<tr>
<td>Internalizing Dysfunction Predicting Initial BMI and Slope.</td>
<td>22526.13</td>
<td>22755.75</td>
<td>2.02 (2)</td>
<td>.364</td>
<td></td>
</tr>
<tr>
<td>Internalizing Dysfunction Predicting 5-Year BMI</td>
<td>22524.58</td>
<td>22750.097</td>
<td>.17 (1)</td>
<td>.680</td>
<td></td>
</tr>
</tbody>
</table>
The first model tested whether pre-surgical Externalizing Dysfunction predicted beginning and ending BMIs as well as the rate of BMI-reduction over time. Overall model fit indices indicated that the path from Externalizing Dysfunction to BMI differences at the 5-year outcome did provide incremental fit to the baseline model (Table 2). Pre-surgical Externalizing Dysfunction was marginally predictive of BMIs at the evaluation date ($\beta = .15, p = .079$) and statistically significant at the five-year follow-up ($\beta = .16, p = .043$), indicating that patients who exhibit more externalizing behaviors pre-surgery are more likely to have higher BMIs both prior to and five-years after surgery. Externalizing Dysfunction was not predictive of the slope ($\beta = -.06, p = .816$), indicating that patients follow a similar rate of BMI-reduction regardless of how much externalizing behaviors they exhibit. The next model tested whether pre-surgical Low Positive Activation/Emotionality predicted the intercepts and the slopes. Overall model fit was not as good as the baseline model (Table 2). Pre-surgical Low Positive Activation/Emotionality was marginally significant at the five-year follow-up ($\beta = .09, p = .091$), suggesting that patients who tend be anhedonic and pessimistic are more likely to have higher BMIs five-years following surgery.

Low Positive Activation/Emotionality was not predictive of BMIs at the evaluation ($\beta = .09, p = .172$) or the slope ($\beta = -.06, p = .767$), indicating that patients follow a similar rate of BMI-reduction regardless of how much Low Positive Activation/Emotionality behaviors they exhibit.

The model in which pre-surgical High Negative Activation/Emotionality was a predictor of pre- and post-surgical BMIs and rate of BMI-reduction across time did not evidence any incremental model fit indices. High Negative Activation/Emotionality was
not associated with pre-surgical BMI ($\beta = .11, p = .200$), post-surgical BMI ($\beta = .09, p = .261$), or rate of BMI-reduction over time ($\beta = -.14, p = .754$).

The model in which pre-surgical Demoralization was used as a predictor of pre- and post-surgical BMIs and rate of BMI-reduction across time yielded no incremental model fit. Specifically, Demoralization was not associated with pre-surgical BMI ($\beta = .06, p = .324$), post-surgical BMI ($\beta = .05, p = .492$), or rate of BMI-reduction over time ($\beta = -.08, p = .714$).

Lastly, the higher-order Internalizing Dysfunction construct was used as a predictor. Model fit indices did not suggest an incremental fit over the baseline model. Specifically, Internalizing and was not associated with higher BMIs at the evaluation date ($\beta = .09, p = .205$), at the 5-year follow-up ($\beta = .08, p = .248$), or rate of BMI-reduction over time ($\beta = -.10, p = .730$).

Overall, the path coefficient indicating pre-surgical Externalizing Dysfunction predicts greater BMIs at the five-year outcome after controlling for age was the only model that provided incremental fit statistics. However, a review of beta weights suggested Low Positive Activation/Emotionality was marginally predictive of greater BMIs at the five-year outcome after controlling for age.

### 3.5 Post-Hoc Analyses

A final set of exploratory analyses were conducted to examine whether the pre-surgical indicators (e.g., the diagnosis of Major Depressive Disorder, scale scores on the MMPI-2-RF, etc.) predicted higher BMIs at the 5-year outcome or rates of BMI-Reduction over time (after controlling for age, measurement error, and the correlation between BMIs at the 5-year outcome and rates of BMI-Reduction over time). Table 3
contains zero-order correlations between the pre-surgical indicators and the latent outcomes after controlling for age. Correlations with the outcome variables were interpreted based on effect sizes outlined by Hemphill (2013), which was described earlier.

Overall, small positive associations were observed with BMIs at the 5-year outcome, such that higher scores on Antisocial Behaviors of the MMPI-2-RF as well as clinician ratings of poorer adherence predicted higher BMIs at the 5-year outcome. Significant association were also observed between the scores on the Low Positive Emotions scale and the Behavior Restricting Fears of the MMPI-2-RF and higher BMIs at the 5-year outcome. No other statistically significant effects were observed.
Table 3. *Associations between pre-surgical criteria, 5-year BMIs, and Rate of BMI Reduction Over Time*

<table>
<thead>
<tr>
<th>Pre-Surgical Criteria</th>
<th>5-year BMIs</th>
<th>BMI Reduction Over Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of Suicide Attempts</td>
<td>.01</td>
<td>.03</td>
</tr>
<tr>
<td>Clinician Rating Form - Adherence</td>
<td>-.10**</td>
<td>.02</td>
</tr>
<tr>
<td>Substance Use Disorder</td>
<td>.04</td>
<td>-.04</td>
</tr>
<tr>
<td>Generalized Anxiety Disorder</td>
<td>.05</td>
<td>.05</td>
</tr>
<tr>
<td>Major Depressive Disorder</td>
<td>.00</td>
<td>.02</td>
</tr>
<tr>
<td>Panic Disorder</td>
<td>.02</td>
<td>.04</td>
</tr>
<tr>
<td>Demoralization (RCd)</td>
<td>.05</td>
<td>-.03</td>
</tr>
<tr>
<td>Low Positive Emotions (RC2)</td>
<td>.13**</td>
<td>-.02</td>
</tr>
<tr>
<td>Antisocial Behaviors (RC4)</td>
<td>.10**</td>
<td>-.04</td>
</tr>
<tr>
<td>Anxiety (AXY)</td>
<td>.05</td>
<td>-.03</td>
</tr>
<tr>
<td>Behavior Restricting Fears (BRF)</td>
<td>.11**</td>
<td>-.01</td>
</tr>
<tr>
<td>Social Avoidance (SAV)</td>
<td>.01</td>
<td>.04</td>
</tr>
</tbody>
</table>

Note. **p < .05; Correlation coefficients are estimated after controlling for age, measurement error, and the correlation between BMIs at the 5-year outcome and rates of BMI-Reduction over time;
CHAPTER 4

DISCUSSION

The current investigation aimed to understand bariatric surgery outcomes within a hierarchical modeling framework. The goal of such an investigation was to help clarify inconsistent results reported in the literature in regards to psychopathology predicting weight loss outcomes by modeling psychopathology in a manner that is congruent with current, theoretical models that controls for psychological comorbidities (c.f., Caspi et al., 2013; Kotov et al., 2011; Krueger & Markon, 2006, Watson, 2005). Indeed, results supported that shared variance in pre-surgical criteria across multiple methods adhere to the contemporary models of psychopathology. Moreover, analyses supported that BMI-reduction over time needs to be modeled as a combination of linear and curvilinear trends, as many individuals regain a small amount of weight from one to five years after bariatric surgery. Moreover, longitudinal weight loss models in this population should consider age as a covariate because the current investigation suggested older adults tend to have a slower rate of change over time, but eventually evidence similar weight loss outcomes as younger individuals by the five-year follow-up. Prediction analyses also evidenced that individuals who are higher in Externalizing Dysfunction (e.g., disinhibited, impulsive, engages in substance use) and Low Positive Activation/Emotionality (e.g. anhedonic, pessimistic, introverted) prior to surgery tend evidence higher BMIs by the five-year outcome than those who are not evidencing those
dysfunctions. Taken together, the results provide a number of implications that warrant further discussion.

4.1 Replication of the Hierarchical Models of Psychopathology

The first set of hypotheses were supported in the current investigation. Indeed, Internalizing Dysfunction was best captured by three lower-order constructs: Demoralization, High Negative Activation/Emotionality, and Low Positive Activation/Emotionality. The factor structure of Internalizing Dysfunction in the current investigation is similar to early theoretical work on the structure of mood and anxiety disorders (Tellegen, 1985; Watson & Tellegen, 1985). Beyond a replication of the hierarchical models typically cited in the literature (c.f., Krueger & Markon, 2006; Watson, 2005), the current investigation also sought to extend the model by incorporating a Low Positive Activation/Emotionality construct into the Internalizing Dysfunction hierarchy. The best fitting structural model of Internalizing/Externalizing Dysfunction in the current sample is depicted in Figure 3.4 (depicted earlier). The two higher-order factors (Internalizing and Externalizing) and the specification of lower-order Demoralization and High Negative Activation/Emotionality are of a similar to those reported across the literature (c.f., Caspi et al., 2013; Kotov et al., 2011; Krueger & Markon, 2006, Watson, 2005). However, Sellbom, Bagby, and Ben-Porath (2008) suggested that the construct of Low Positive Activation/Emotionality was a unique predictor of Major Depressive Disorder and Social Phobia. Indeed, the best fitting structural model in the current investigation implied that Major Depressive Disorder and measures of low positive emotions and social avoidance fit best under a Low Positive Activation/Emotionality factor that was distinct from Demoralization and High Negative
Activation/Emotionality. Taken together, the best fitting structural model for Internalizing Dysfunction in the current investigation was similar to factor analytic work by Watson & Tellegen (1985).

The current evaluation of the hierarchical structure of internalizing dysfunction also has implications for the construct validity of diagnoses and their measurement. For example, Watson (2005) provided empirical evidence that Generalized Anxiety Disorder had more in common with distress-based disorders than it did with fear-based disorders. Measures such as the Generalized Anxiety Disorder – 7 (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) is closely tied to DSM diagnostic criteria for Generalized Anxiety Disorder and is a commonly used outcome measure for the assessment of anxiety-related symptoms in bariatric surgery settings (Marek, Heinberg, Lavery, Rish, & Ashton, 2016). As evidenced in both the current investigation and in previously published research (c.f., Kreuger & Markon, 2006; Sellbom et al., 2008; Watson, 2005), Generalized Anxiety Disorder is more similar to distress (or Demoralization) than it is with other anxiety disorders. Another example is the BDI. As reviewed earlier, the BDI assesses depressive features that are more closely related to Frank’s (1974) and Tellegen et al.’s (1985) construct of Demoralization. Unlike the Hamilton Rating Scale for Depression (HRSD; 1960), the BDI taps into more cognitive and affective domains of MDD, whereas the HRSD assesses anhedonic features of the disorder that are more congruent with Low Positive Activation/Emotionality. It is therefore plausible that mixed findings on associations between depression, anxiety, and weight loss following bariatric surgery are confounded by inconsistent measurement of those constructs. Mapping our
current models and measures onto the hierarchical models of psychopathology will likely provide clearer outcome results.

Although the database did not contain enough indicators to differentiate between Disinhibition and Antagonism, the indicators did converge on a broad Externalizing Dysfunction factor. Because the indicators had more in common with impulse-control behaviors, it is likely that the broad Externalizing Dysfunction factor was more similar to its lower-order counterpart, Disinhibition, than it was to Antagonism. Differentiating between Disinhibition and Antagonism in this setting would likely offer a benefit in understanding how Externalizing Dysfunction contributes to poorer weight loss outcomes. For example, Antagonism (relational aggression) may be more strongly associated with appointment non-adherence than weight loss outcomes whereas Disinhibition (impulse control) may demonstrate stronger associations with weight loss outcomes than with appointment adherence. Such differential analyses would also be useful in understanding the role of LOC in bariatric surgery outcomes as well as the increased prevalence of alcohol use disorders, where the theory of “addiction transfer” has been gaining recent attention (Sogg, 2007). Sogg (2007) reviews a clinical observation that suggests that patients who have problems with binge eating behaviors or substance use prior to surgery are not only at a higher risk of exhibiting those problems after surgery, but are also at a higher risk of developing new impulse-control disorders. Better understanding how whether or how levels of disinhibition change after surgery may provide better insight into why some patients maintain or go on to develop new impulse-control behaviors.
The structural modeling analyses had a few limitations that should be noted. The first limitation is that the clinician had test scores and medical chart review information at the time of the evaluation. The use of the MMPI-2-RF and a medical chart history on a history of psychopathology may have influenced diagnoses and clinician ratings, which, in turn, would influence the structural models of psychopathology in the current investigation. Another limitation is that a thought disorder construct could not be tested due to a lack of indicators. Individuals with thought disorders are typically not obtaining surgery in the setting where data were collected; however, measures of ideas of reference predicted patients who reported post-operative body image dissatisfaction (Pona et al., 2016) in this population. Including measures such as body image dissatisfaction in addition to a measure, such as the MMPI-2-RFs Ideas of Persecution scale, may offer an interesting avenue in understanding how lower-order thought disorder constructs, such as paranoia, contribute to the development or maintenance of body image dissatisfaction and/or dysmorphia. Nonetheless, the contemporary models of psychopathology replicated in a sample of bariatric surgery patients.

4.2 Non-Linear BMI-Reduction Over Time as a Function of Age

As reviewed earlier, weight loss after bariatric surgery is not linear - particularly following the one-year, post-operative time point (Margo et al., 2008; Mechanick et al., 2013; O’Brien et al., 2004; Odom et al., 2010; Sjostrom et al., 2007). Despite this non-linear trend, many previous studies reviewed in this dissertation relied on inferential statistics whose assumptions included linearity (e.g., ANOVAs), homogeneity of error, and that all individuals have a similar starting point (intercept) and have a similar rate of change over time (slope). Moreover, many of these traditional statistical techniques do
not account for missing data across time. Latent growth curve models (Ducan et al., 1999) offer flexibility above traditional techniques that are ideal to be used in bariatric surgery outcome research because latent growth curve models can model non-normal data, measure variances around the intercept and slope, controls for measurement error, and handles missing data across time. Therefore, it was hypothesized that a piecewise model would be the best fit for the data.

Although analyses from the current investigation provided some mixed evidence for model fit and piecewise models did not converge, the best fit for the data indicated that BMI-reduction over time is non-linear in that most individuals tend to follow a negative, linear decrease in BMI up to the one-year follow-up and then begin regaining a small amount of weight by the 5-year outcome. Importantly, the variance around the BMIs at the start and the end of the trajectories were statistically significant, implying that there was a lot of variability in BMIs both prior to and five years following bariatric surgery.

Analyses also revealed that an association between pre-surgical BMI and the rate of BMI-reduction was statistically significant. Not surprisingly, individuals with a higher pre-surgical BMI tended to evidence a faster rate of change over time as compared to individuals who started with lower BMIs in the current investigation. Model fit also improved when the non-linear trajectories were modeled as a function of age. The model in this investigation suggested that older adults tend to have a slower rate of BMI-reduction over time compared to younger adults. This finding is comparable to published studies suggesting that although older adults benefit from bariatric surgery (e.g., improved quality of life, reduction of medical comorbidities, etc), they tend not to lose as
much weight as younger adults (Sugerman et al., 2004; Villareal et al., 2005; Villareal et al., 2011).

The analyses also had a few limitations. The quadratic and piecewise model terminated in error. Although the non-linear model yielded factor coefficients that optimally fit the trajectory, the non-linear model was derived from the software vs. a theoretical specification. In addition, baseline model fit indices for the non-linear model with no covariates (e.g., RMSEA = .092) suggested that other alternative models (e.g., quadratic) may better fit the data. It is possible that the most optimal model is a quadratic or piecewise model. Another instance of inconsistencies was when RMSEA and CFI estimates disagreed in regards to model fit. Kenny, Kaniskan, & McCoach (2015) used Montecarlo simulations to explore why RMSEA may suggest inadequate fit whereas CFI would predict good fit when a model is properly specified. The authors suggest that models with small degrees of freedom affect RMSEA estimates and they argue against using RMSEA as a fit index when sample size or degrees of freedom are small. Other authors have also supported that models with low degrees of freedom result in higher than expected RMSEA values (Breivik & Olsson, 2001; Kline, 2015). Indeed, the latent growth curve models used in the investigation had small degrees of freedom and may be affecting the RMSEA estimates. In essence, CFI is more robust when specifying models with small degrees of freedom. Nonetheless, future research should continue to explore and test these models to ensure weight loss across time is being modeled appropriately.

Another limitation is the lack of external criteria throughout the trajectory that may serve as time-varying predictors. For example, dietary adherence may account for weight gain from the one-year to the five-year outcomes. Moreover, adding time-varying information
to the models such as medical complications early in the BMI-Reduction trajectory or the change in caloric intake over time would likely improve overall model fit. In summary, modeling weight loss data in a non-linear fashion as a function of age yields an adequate fit for understanding BMI-reduction across time in the current bariatric surgery sample.

4.3 Pre-surgical Psychopathology and Bariatric Surgery Outcomes

The final set of analyses tested the hypotheses that pre-surgical criteria modeled in congruence with the hierarchical models of psychopathology can predict differences in BMI at the evaluation, BMI at the 5-year outcome, and differences in the rate of change across time after controlling for age. Although psychopathology did not predict any variability in terms of the rate of change in BMI across time (likely because there was little variability left unaccounted for around the slope), individuals with greater levels of Externalizing Dysfunction evidenced higher BMIs at both the pre-surgical evaluation and the 5-year post-surgical outcome time point. No differences in the rate of BMI-reduction over time or BMI at the pre-surgical or 5-year outcome were accounted for by Internalizing Dysfunction, with the exception of a marginally significant effect that implied that patients with more pre-surgical Low Positive Activation/Emotionality evidenced greater BMIs at the 5-year follow-up. These findings warrant further discussion.

Studies that have examined post-surgical criteria (such as dietary adherence, loss of control, executive functioning) to predict weight regain have collectively implied that factors associated with Externalizing Dysfunction were related to suboptimal weight loss outcomes in this population (c.f., Conceição et al., 2014; el Chaar et al., 2011; Gould, Beverstein, Reinhardt, & Garren, 2007; Poole et al., 2005; Spitznagel et al., 2014).
Moreover, Marek et al., (2015) reported that patients who score higher on measures of Behavioral/Externalizing Dysfunction on the MMPI-2-RF evidenced suboptimal one-year weight loss outcomes in a sample of gastric bypass patients. These findings are not exclusive to bariatric surgery patients because similar associations have also been evidenced in non-surgical weight management patients (Cummings & Lentendre, 2009; Orth, Madan, Taddeucci, Coday, & Tichansky, 2008). Indeed, the current investigation extends these findings to the 5-year post-surgical bariatric surgery patients. Because patients who evidence more externalizing behaviors prior to surgery are likely to achieve suboptimal weight loss outcomes compared to patients who do not evidence Externalizing Dysfunction, pre-surgical intervention should focus on helping the patient gain better control over their impulse-control. Conversely, pre-surgical treatment of externalizing disorders are likely not to work as well as treatment for internalizing disorders, as individuals with externalizing disorders tend not to respond as well to treatment, likely because individuals with externalizing disorders are also more likely to be nonadherent to appointments and treatment recommendations (Roth & Fonagy, 2006). Therefore, maintaining contact with patients who evidence more pre-surgical externalizing psychopathology may warrant better adherence, particularly if the patient notices they are not losing as much weight as they expected.

In regards to Internalizing Dysfunction, the current study reports that there is a marginally significant trend between Low Positive Activation/Emotionality and BMIs at the 5-year follow-up. Low Positive Activation/Emotionality encompasses the inability to experience positive emotions (even if engaging in activities they enjoy), anhedonia, pessimism, and introvertedness and is a good predictor of a Major Depressive Disorder or
Social Phobia diagnosis. (Ben-Porath/Tellegen, 2008/2011; Sellbom, Bagby, & Ben-Porath, 2008; Watson & Tellegen, 1985). Prevelance for Major Depressive Disorder has been found to decrease over time in some longitudinal bariatric surgery studies (de Zwaan et al., 2011) whereas other studies note that the diagnosis returns after surgery (Mitchell et al., 2014). If a patient is experiencing symptoms such as anhedonia or has social phobic tendencies, it is possible that they are likely not engaging in physical activity and/or going to the gym. Post-operative physical activity is a predictor of weight loss maintenance in other longitudinal outcomes studies in bariatric surgery populations (Livhits, et al., 2010; Stegan, Derave, Calders, Laethem, Pattyn, 2011). It is possible that, to some extent, individuals more prone to experiencing Low Positive Activation/Emotionality are less engaged in the surgical process and thus, are failing to engage in activities that promote weight loss maintenance. Helping patients gain insight into the benefits of exercise both prior to and following surgery may help these patients become more active and achieve and maintain good weight loss outcomes.

Pre-surgical Demoralization and High Negative Activation/Emotionality were not predictive of the BMI-reduction over time nor were they predictive of BMIs at the time of the evaluation or at the five-year follow-up. Patients who experience demoralization prior to surgery present as being distressed, sad, unhappy, and frustrated with current life-circumstances, (Ben-Porath/Tellegen, 2008/2011). As reviewed earlier, Demoralization is likely a contributing construct motivating individuals to seek medical and psychological interventions for their symptoms (Fava et al., 1995; Frank, 1974) in an effort to relieve their distress. Patients in this population are likely distressed about their weight and medical comorbidities and thus, present for and proceed with bariatric surgery. Because
most patients evidence weight loss and significant reduction (or resolution) of their medical comorbidities, their Demoralization is likely relieved as a result. Another hypothesis is that patients who are more sensitive to Demoralization and High Negative Activation/Emotionality tend to maintain weight loss outcomes due to some other maladaptive factors, such as a belief that the weight loss outcome did not meet their expectations, body image dissatisfaction, or a fear of weight regain. Future research should incorporate the aforementioned external criteria into data collection efforts to better understand how post-operative factors contribute to weight loss maintenance and/or weight regain.

The SEM analyses are methodologically beneficial because the latent constructs measure similarities across indicators (e.g., what is similar between the diagnosis of MDD and a measure of Low Positive Emotions on the MMPI-2-RF) and parses out measurement error and unique variability to the extent possible. Interestingly, the post-hoc analyses that examined diagnoses, MMPI-2-RF scale scores, and clinician ratings of adherence independently yielded small to no meaningfully observed effect sizes with outcomes. As reviewed in this dissertation, diagnostic criteria were atheoretically developed and may be the source of inconsistent findings in the bariatric surgery literature. Had diagnostic criteria been the sole examination of outcome in the current investigation, it may have been falsely inferred that pre-surgical psychopathology does not predict longer term weight loss outcomes in this setting. A strength of using a measure such as the MMPI-2-RF is that the instrument was theoretically designed in accordance to the hierarchical models of psychotherapy. Indeed, a small effect size in the domains of Externalizing Dysfunction and a measure of Behavior-Restricting Fears in
addition to a marginally significant effect between a measure of Low Positive Activation/Emotionality and 5-Year BMIs, all measured pre-surgery, predicted higher BMIs at the five year outcome. These results are consistent with what the latent construct analyses implied. Taken together, the MMPI-2-RF may be a good example of incorporating hierarchcial models of psychopathology into clinical practice. Lastly, the clinician rating of poor adherence was also related to higher BMIs at the five-year outcome. Although clinician ratings are subjective, they are based on multiple sources of information (e.g., adherence to medication, psychotherapy, nutritional recommendations, using Continuous Positive Airway Pressure for Obstructive Sleep Apnea, etc). Overall, analyses of the individual indicators in relation to outcome indicate that using theoretically derived measures and multiple sources of information can provide more consistent results than relying on psychiatric diagnoses.

The predictive analyses also had several limitations. On one hand, the analyses implied that patients who evidence higher levels of pre-surgical Externalizing Dysfunction and Low Positive Activation/Emotionality tend to have higher BMIs five-years post-surgery as compared to patients who do not evidence those tendencies. However, one may argue that there is a loss of specificity in the current study’s SEM models. The psychological constructs used in the analyses were broad and although they point toward common behaviors and symptoms that underlie that construct, one cannot gather definitive clinical applications from the results as they stand. Although the MMPI-2-RF may serve as a means toward bridging theory and practice, effect sizes were small. Another limitation was the complexity of the model and the size of the beta weights that were estimated. The a-priori power analyses were conducted based on medium effect
sizes when, in fact, many observed predictive effect sizes were small. Therefore, one can conclude that the present analysis models were under-powered. Lastly, because the baseline model fit indicies for the non-linear BMI-Reduction model were mixed and other growth models were not able to be modeled with this database (e.g., quadratic, piecewise), it is possible that a better fitting longitudinal model would yield different predication coefficients.

4.4 Possible Range Restriction in the Current Investigation

An important methodological consideration that can be inferred is that the current study evidenced range restriction. Recall that 38.1% of the sample engaged in a possible under-reporting response style on the MMPI-2-RF. This statistic is slightly higher than those reported in previous studies (Ambwani et al., 2013; Tarescavage et al., 2013), likely because Ambwani et al., (2013) and Tarescavage et al., (2013) reported under-reporting statistics using a pre-surgical sample that included patients who did not necessarily obtain surgery in the end. The current investigation examined patients who were cleared by the Cleveland Clinic as being appropriate candidates for surgery and obtained surgery. Under-reporting makes it difficult for clinicians to accurately assess if risk factors are present. If a patient engages in an under-reporting response style on the MMPI-2-RF, they do so across the evaluation as evidenced in other samples (Crighton, Tarescavage, Gervais, & Ben-Porath, 2015; Forbey et al., 2013). Indeed, the current sample evidenced lower prevalence statistics in reference to psychopathology and also produced lower than expected scores on the selected MMPI-2-RF scales used in the analyses. As a consequence of underreporting, range restriction likely inflates Type II
Error and artifactually attenuates prediction coefficients. To date there is no method to correct for range restriction in SEM models.

Another methodological challenge that may attenuate observed associations between psychopathology and weight loss outcomes is when presurgical assessment data are relied upon to guide preoperative patient care. For example, individuals identified pre-surgically as experiencing emotional problems are more likely to receive, and respond to, brief interventions compared with those manifesting externalizing dysfunction (Roth & Fonagy, 2006). Successful intervention may preclude or attenuate associations between presurgical measures of Internalizing Dysfunction and postoperative weight loss. In other words, if Internalizing Dysfunction was not assessed and was left untreated, it might negatively impact postsurgical outcomes, but, as it stands, presurgical interventions to reduce this risk factor would attenuate associations between the construct and weight loss. Taken together, it is possible that prediction analyses were based on a relatively healthy cohort or a cohort who were less likely to report psychopathology.

4.5 **Conclusions**

Overall, bariatric surgery weight loss outcomes as a result of a Roux-en-Y gastric bypass suggest that most patients evidence a similar rate of BMI-reduction up until the one-year, post-surgical follow-up. From that point to the five-year post-surgical follow-up, most patients evidence a small amount of weight gain. BMI reduction across time was slower in older patients and patients with a lower BMI at the time of the evaluation. Additional variability in five-year BMI differences were accounted for by pre-surgical Externalizing Dysfunction and Low Positive Activation/Emotionality, such that patients
who were more impulsive, engaged in undercontrolled behaviors, were deemed less likely to be adherent, or were more anhedonic, pessimistic, introverted, and less likely to experience positive emotions evidenced higher BMIs at the 5-year outcome than patients who did not evidence these symptoms/behaviors. Clinicians who observe symptoms, features, or behaviors in line with these constructs should reinforce the importance of follow-up visits, focusing on enhancing patient's self-control as a target for intervention, and more closely monitor patients who may be less engaged in the process.
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