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Does Overweight/Obesity Moderate the Association between ADHD and Internalizing Difficulties in Young Adults?

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Abstract

This study's objective was to investigate if ADHD symptoms and BMI are associated with internalizing impairments of depression, anxiety, stress and lower self-esteem in college students. It was predicted that higher ADHD symptoms would be associated with elevated depression, anxiety, stress, and low self-esteem, especially if BMI fell in the overweight/obese range. Undergraduate students [N= 580; Mean (SD) age= 20.7 (3.10)] from an urban campus completed an online survey comprising self-report measures of demographics, height/weight, attention and hyperactivity/impulsivity (Barkley Deficits Executive Functioning Scale ADHD-Executive Function Index), depression, anxiety, stress (all using the Depression Anxiety and Stress Scale) and self- esteem (Rosenberg Self-Esteem Scale**)**. Individuals were grouped based on their BMI and ADHD severity. They were classified as: "Controls" (Low ADHD/Low BMI), "High BMI" only (High BMI/Low ADHD), "High ADHD" only (High ADHD/Low BMI) and "Comorbid" (High ADHD/High BMI). Chi-square analyses showed that High ADHD and High BMI were not significantly related. Second, greater ADHD, but not BMI was significantly related to depression and stress, and lower self-esteem. BMI was only significantly related to the internalizing impairment of anxiety. Main effects of ADHD and BMI on anxiety were qualified by a significant ADHD x BMI interaction. Students with both elevated in ADHD symptoms and overweight/obesity were at highest risk for elevated anxiety. These findings can contribute to the diagnostic and treatment procedure of those with ADHD, obesity and comorbid disorders. This study adds to the literature by collectively concentrating on variables of ADHD, obesity and internalizing factors, in a non-clinical college student sample.

Keywords: ADHD, obesity, depression, anxiety, stress, self-esteem, college students, young adults

Does Overweight/Obesity Moderate the Association between ADHD and Internalizing Difficulties in Young Adults?

Attention-Deficit/Hyperactivity Disorder: Phenomenology and Developmental Course

Attention deficit hyperactivity disorder (ADHD) is a highly prevalent, impairing neurodevelopmental disorder characterized by core deficits in inattention, hyperactivity, and/or impulsivity [American Psychiatric Association (APA), 2013]. Inattention encompasses difficulty with sustained attention and sustained mental effort, forgetfulness, poor organizational skills and distractibility (APA, 2013). Hyperactivity and impulsivity symptoms include difficulty sitting for periods of time, awaiting one's turn, and participating in quiet activities, along with fidgeting, restlessness, excessive talking and interrupting others. Impulsivity results in inaccurate and inappropriate statements or behaviors due to inadequate control, planning and thoughts of the aftermath (Solanto et al., 2001).

Oftentimes, ADHD is first evident in early childhood; however, for many, the disorder follows a chronic course into adolescent and young adult years (APA, 2013), with 50 to 75% of those with childhood ADHD consistently meeting ADHD criteria in adulthood (Pawaskar, Fridman, Grebla, & Madhoo, 2019). Estimated persistence of the disorder is, however, influenced by how ADHD is defined and the severity level being analyzed (Faraone, Biederman & Mick, 2005). Faraone et al. (2005) explored the persistence of ADHD from childhood to adulthood by conducting a meta-analysis of follow-up studies. Approximately 15% of individuals exhibited a persistent course at 25 years old when "persistence" was defined as meeting full DSM-IV ADHD diagnostic criteria (Faraone et al., 2005). However, as many as 40 to 65% of individuals continued to show significant symptoms and/or impairment, despite not meeting full criteria for a diagnosis according to the DSM-IV. Of particular relevance to adults

presenting with ADHD-like behaviors, several symptoms of the disorder may not be developmentally sensitive, potentially negatively affecting identification of the disorder beyond childhood. For example, indicators of hyperactivity are more commonly observed in childhood rather than adulthood (Faraone et al., 2005).

To further understand the persistence of ADHD, Lahey et al. (2016) examined children from 4-6 years of age through to 18 years of age to determine functional outcomes and impairment. There were 125 children at the age of 4-6 years who were diagnosed according to the DSM-IV criteria for ADHD and 130 matched typically developing children. Those who had been diagnosed with ADHD in preschool presented with more ADHD symptoms in adolescence compared to their matched peers. Furthermore, those who had been diagnosed with ADHD as children displayed more symptoms of oppositional defiant disorder, conduct disorder, anxiety, and depression across ages of 4 to 18 years (Lahey et al., 2016). Evidence of greater functional impairment and risky behaviors were also present. This study reinforced existing literature on the validity of diagnosing ADHD at a young age, and to predict long-term impairment, as well as showing the persisting nature of the disorder across development.

In 2013, the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5) (APA, 2013) made significant changes to how ADHD is diagnosed. First, for adults, they lowered the required number of symptoms in the core deficits of inattention and hyperactivity/impulsivity to be five in one or both domains, as opposed to six symptoms as had been the case for the DSM-IV (note, children still required six or more symptoms in one or both domains) (APA, 2000). The second change was increasing age of onset from age 7 years to 12 years of age (APA, 2000; 2013). Matte et al. (2015) evaluated the reliability and validity of the DSM-5 ADHD criteria among a Brazilian birth cohort followed up at 18-19 years of age, in a

clinical adult population. New changes in the DSM-5 were envisioned to benefit adults, who faced impairments in their everyday life due to ADHD symptoms, but who may have had difficulty remembering how symptoms manifested in early childhood, and for whom the diagnostic criteria may not be sensitive to how symptoms change across development. In this study, Matte et al. (2015) found an occurrence of ADHD to be 3.55% based on DSM 5 criteria in a young adult population, while DSM-IV criteria showed a 2.8% occurrence. Based on the required number of symptoms for each core deficits, Matte et al. (2015) findings supported the new change of the DSM 5 of cut-off symptoms to be five for inattention, and also found that four could be the cut-off symptoms number for hyperactivity/impulsivity. This data supported the new criteria of the DSM-5 and found it be effective for diagnosing in young adults by occurrence rates increasing by 27%. Diagnosing ADHD in adults has shown greater efficacy by DSM-5 criteria.

Adult-Onset ADHD

Follow-up studies of young children diagnosed with the disorder do not answer a critical question, however, about the emergence of ADHD across different periods of development. Yet, a controversial debate among scholars in the research and clinical community is whether ADHD is strictly a childhood developmental disorder that persists into adolescence/adulthood or if ADHD could *emerge* later in life, in late adolescence or adulthood. In other words, may there be new cases of ADHD in adults who had none or very few symptoms in childhood? That is, is there such a thing as “late-onset” ADHD? Researchers have found contrasting results on this topic with some support for childhood-onset and others supporting an adulthood-onset of ADHD.

Critics of this work state that these studies have failed to address comorbid disorders, other mental disorders, health issues, and substance use that may account for the ADHD-like presentation, or to conduct psychiatric assessments to adequately evaluate these issues or undiagnosed childhood ADHD, which may be accounting for a person's presentation. Ultimately, these factors can mimic or lead to similar symptoms of ADHD, when it is actually not ADHD causing impairments in adulthood. Sibley et al. (2018) investigated cases of late-onset ADHD through a prospective follow-up study, which included numerous measures and a psychiatric assessment. A comparison group subsample of 239 participants who did not have ADHD in childhood was also used. Baseline evaluations in childhood were conducted at an average age of 9.89 years and assessments continued into adult years to an average age of 24.40 (Sibley et al., 2018). Measures assessed ADHD symptoms, impairments, substance use and other psychiatric disorders. Results were analyzed based on the different assessments to exclude all other possible causes of ADHD-resembling symptoms. For adult-onset ADHD, 47 participants met DSM-5 criteria for an ADHD diagnosis, but after eliminating individuals without impairment, an adult onset, substance use, other mental disorders and lack of cross-situational symptoms, only two participants remained (Sibley et al., 2018). Two participants (0.8%) of 239 were considered to be true cases of late-onset adult ADHD, whereas 95% of individuals who had been diagnosed with ADHD were excluded. Mostly – for 53% adolescent and 83% of adults - individuals were excluded because their ADHD-like symptoms were attributed to another mental disorder or to heavy substance use (Sibley et al., 2018). Thus, the results of this study did not support the late-onset phenomenon (Sibley et al., 2018). The authors concluded that investigating the individual's psychiatric history and conducting a longitudinal study increases the overall

knowledge of the individual by assessing their history, onset, symptoms, behaviors and impairments they experience.

In contrast to Sibley et al.'s (2018) findings, Moffitt et al. (2015) showed evidence in support of a late-onset phenotype. They too conducted a prospective longitudinal study to investigate adult ADHD. Evaluations of follow-forward cases of individuals diagnosed with ADHD in childhood and follow-back cases of individuals diagnosed with adult-diagnosed ADHD were analyzed. The sample consisted of a birth cohort from 1972 to 1973 of 1,037 participants recruited into the Dunedin Multidisciplinary Health and Development Study. Assessments and interviews were conducted until the age of 38 years. For childhood ADHD, 61 children were diagnosed using the DSM-III and for adulthood ADHD 31 adults were identified using the DSM-5 at age 38 (Moffitt et al., 2015). Measures comprised onset, cross-setting confirmation, comorbid disorders, neuropsychological assessment and impairments. Based on the sample, ADHD in childhood had 6% prevalence compared to 3% in adulthood (Moffitt et al., 2015). The follow-forward data revealed that three participants (5%) who had been diagnosed with ADHD in childhood continued to have ADHD in adulthood. Likewise, those participants made up the 10% of adults diagnosed with ADHD who had a history of childhood ADHD based on the follow-back data (Moffitt et al., 2015). Thus, 28 of the 31 adults (90%) diagnosed with ADHD *did not* have the disorder in childhood. Outcomes demonstrated that the persistence of ADHD from childhood to adulthood decreased and many were diagnosed with ADHD later in life, suggesting late-onset or other factors presenting and resembling inattention and hyperactivity/impulsivity symptoms. Also, Moffitt et al. (2015) attributed adult ADHD to possibly stem from other comorbid disorders and found there to be consistent substance use among the adult population. Thus, the adult phenotype remains an important area of exploration.

What is clear for both the Sibley et al. (2018) and Moffitt et al. (2015) studies is that adults presenting with high levels of ADHD symptoms experience significant impairment, and are a group of individuals with great clinical need.

ADHD and Impairment

In addition to presenting with the core symptoms of ADHD, individuals with the disorder also must exhibit impairment across multiple settings (APA, 2013). It is well established that individuals with ADHD face functional impairments and negative psychosocial outcomes both currently and in the long-term (Barkley, 1997; Cadman et al., 2016). Functional impairments are present in education and academic performance, occupational setting, social settings with students and family, and are evident in aggression and risky behavior, such as suspensions and expulsions (Lahey et al., 2016; Barkley, 1997). Furthermore, those with ADHD encounter greater risks of comorbid disorders such as substance misuse, depression and anxiety (Cadman et al., 2016; Barkley, 1997; Pawaskar et al., 2019). Individuals with ADHD also exhibit lower self-esteem than non-ADHD peers (Pawaskar et al., 2019).

Longitudinal Studies with Childhood Onset

A six-year follow-up study by Cadman et al. (2016) analyzed factors that would predict psychosocial comorbidity and functional impairments in those with ADHD at follow-up age 14- to 24-years-old. The sample comprised 5-17 years olds from the International Multi-Centre ADHD Genetics (IMAGE) Project who met criteria for DSM-IV Combined Type ADHD. Cadman et al. (2016) carried out a follow-up assessment 6-years later, measuring ADHD, psychiatric and emotional symptoms, drug use and police encounters. The non-ADHD/control sample was from the Adult Psychiatric Morbidity Study 2007, and comprised 221 subjects aged 16 to 23 years old. The ADHD participants were categorized into “Persistent ADHD,” “Residual

Sub-Threshold ADHD" and "Fully Remitted ADHD." Follow-up data indicated that the Persistent ADHD group scored higher on fatigue, concentration/memory problems, sleep disturbance, anger, anxiety, compulsions, and emotional instability, compared to the other groups (Cadman et al., 2016). Also, the Persistent and Residual Sub-Threshold ADHD groups had higher rates of drug use and police encounters. Depression and depressive ideas, however, was not a significant psychosocial comorbidity. Results highlighted that individuals with consistent elevated inattention and hyperactivity/impulsivity symptoms were continuously experiencing impairments in their everyday life, which negatively affected their quality of life.

Continuing the trend of exploring prospective studies, Klein et al. (2012) conducted a 33-year follow-up study to analyze impairment and functional outcomes of men who had been diagnosed with ADHD as boys. The ADHD subjects (probands) were 135 white males, first evaluated at a mean age of 8 years old and then re-evaluated at the mean age of 41 years old. The control group consisted of 136 subjects without ADHD (Klein et al., 2012). At 33-years follow-up, probands (22%) were more likely to have ADHD compared to controls (5.1%), showing the chronic nature of the condition for a sizeable number of individuals (Klein et al., 2012). Psychiatric comorbidity was present; with 16.3% of probands meeting diagnostic criteria for antisocial personality disorder, while this disorder was not present in the comparison group. Interestingly, no differences in rates of mood and anxiety disorders were seen across the two groups. Moreover, probands displayed significantly higher rates of incarcerations and deaths than controls. At 41 years, probands, on average, had lower occupational achievement, fewer educational years, lower socioeconomic status, lower annual salaries, lower social functioning and more divorces, compared to the comparison subjects (Klein et al., 2012). A pattern is illustrated among individuals with childhood ADHD, on average, experiencing significant,

negative functional impairments and more negative outcomes across the lifespan. Although these group differences are observed, both Klein et al.'s (2012) and Cadman et al.'s (2016) studies show that among individuals who were diagnosed with ADHD in childhood, significant heterogeneity in outcomes is observed. This indicates that some may have effective coping strategies and better adjustment to combat the negative impact of their symptoms on daily life. Access to appropriate evaluation and treatment is also a critical factor.

Impairment in Adults with ADHD

Among adults, fewer than 20% are diagnosed and/or treated for ADHD; this means that most adults who experience ADHD symptoms are not diagnosed or treated (Pawaskar, Fridman, Grebla, & Madhoo, 2019). Pawaskar et al. (2019) compared outcomes for adults who had a self-reported ADHD diagnosis to adults who reported clinically significant ADHD symptoms, but who had never received a clinical diagnosis. Data was gathered from previously collected data from the VALIDATE study in 2012 and 2013, which consisted of an enormous survey that assessed internalizing problems, work productivity and self-esteem in regards to ADHD symptoms. The two groups consisted of 444 subjects diagnosed with ADHD (mean age 42.5 years) and 1,055 subjects with symptomatic ADHD (mean age 43.9 years). Subjects diagnosed with ADHD were matched with subjects with symptomatic ADHD (undiagnosed cases of ADHD) within the same sex-by-age group strata (ages 18-39, 40-54, and 55+ years) by using propensity score matching (Pawaskar et al., 2019). Following matching, individuals diagnosed with ADHD (436 subjects) revealed lower pain/discomfort, anxiety, depression and less impairment in daily activities than those in the symptomatic group (867 subjects) (Pawaskar et al., 2019). Participants with a clinical diagnosis of ADHD also experienced higher work productivity and self-esteem than those who were symptomatic, but undiagnosed. In other words,

those with symptomatic, undiagnosed ADHD had worse outcomes and faced greater impairments in health and psychosocial factors than those with a diagnosis (Pawaskar et al., 2019). These undiagnosed cases of ADHD may be due to unawareness of problems, effective lifestyles coping and adaption mechanisms (Pawaskar et al., 2019). Individuals diagnosed with ADHD can receive treatment, and develop skills and coping strategies that may positively influence their life.

The impairment associated with ADHD in multiple domains of functioning places individuals at risk of psychiatric comorbidity. This is particularly pertinent for adults with ADHD, who show greater comorbidity rates compared to children with ADHD (Kessler et al., 2006; Klein et al., 2012). In a sample of 3,199 adults aged 18–44 years old, those with ADHD showed a high rate of comorbid disorders (Kessler et al., 2006). Adult ADHD prevalence was 4.4%. Disorders occurring at a higher rate in adults with ADHD were mood disorder with a frequency of 38.3% and anxiety with frequency of 47.1%, compared to the 11.1% and 19.5% of adults who had no diagnosis of ADHD, respectively (Kessler et al., 2006).

Severe symptoms and high rates of impairment can have a negative impact on a person's self-esteem. Clinically, it is common for individuals to report that their self-worth is low, that they do not understand why they cannot "be an adult" and meet their own, their partner's or family members', or society's expectations of them. Harpin, Mazzone, Raynaud, Kahle, and Hodgkins (2013) reviewed the literature on the long-term effect of ADHD on self-esteem at different developmental stages. Negative concepts of the self may result in maladaptive coping techniques, such as avoidance and procrastination (Harpin et al., 2013). Harpin et al. (2013) evaluated 12 databases of peer-reviewed research articles published during the period of January 1980 to December 2011 of treated and untreated ADHD children, adolescence and adults,

looking at long-term outcomes (i.e., two years or longer). There were 127 articles on self-esteem and social function with ADHD, having participants ranging from 12 to 8,158 subjects, divided into groups of 6-12 year-old children, 13-17 year-old adolescents, 18-24 years of young adults and 25 years and older of adults. Findings show that those with untreated ADHD had self-reported lower self-esteem, than individuals with ADHD who were treated. Low self-esteem stemmed from poor relationships, inadequate social skills and limited activities or hobbies (Harpin et al., 2013). This finding was seen in all age groups and for both males and females. The results again demonstrate the critical importance of access to treatment for individuals with ADHD. Encouragingly, the benefits of treatment were seen irrespective of pharmacological and nonpharmacological treatment modalities; all produced effective results (Harpin et al., 2013).

ADHD and Internalizing Outcomes in College Students

Although the studies described above have looked at the association of ADHD and impairment among adults, none focused specifically at college students. The college years are a time of marked identity, cognitive and social development (Long, 2012); therefore assessing psychosocial outcomes in this specific group is essential.

Anastopoulos et al. (2018) assessed the rates and patterns of comorbid conditions among a large, diverse sample of 18-22 year old first year college students with ADHD. The authors employed a comprehensive, multi-method approach with an expert review panel. Of concern, 55% of students with ADHD had at least one comorbid disorder, and 31.8% had two or more conditions, compared to a much lower rate among students without ADHD - 11.2% had one comorbid non-ADHD disorder and 4.0% had two more comorbid non-ADHD disorders (Anastopoulos et al., 2018). Contributing to the higher comorbidity rates within the ADHD group were Major Depressive Disorder, Generalized Anxiety Disorder, Learning Disabilities,

Stress-Related Disorders, Oppositional Defiant Disorder and Conduct Disorder. Specifically, for depressive disorder, anxiety disorder and stress-related disorders, those with ADHD had 32.3%, 28.6% and 7.3% rate of comorbidity, respectively, compared to those without ADHD of 5.4%, 3.6% and 0.9%, respectively (Anastopoulos et al., 2018). Gender differences in comorbidity were evident, with females in the ADHD group scoring higher on mood and anxiety disorders, whereas males with ADHD scored higher on conduct disorder.

The finding also appears to exist in the opposite direction, such that individuals with anxiety and depression also tend to show higher rates of ADHD than expected given rates of the disorders in the general population. Harrison, Alexander, and Armstrong (2013) examined whether or not depression, anxiety or stress was associated with increased self-report of ADHD. They investigated whether postsecondary students (education after high school) from a health or counseling center reported symptoms of ADHD. Students (N=98) with a mean age of 22.6 years seeking services from the combined health and counseling services were recruited from a Canadian university (Harrison et al., 2013). Participants self-reported their mental health by a variety of checklists. Results found a high percentage of students (21% to 35%) scored in the critical range on a measure of adult ADHD, which may indicate that they had undiagnosed ADHD (Harrison et al., 2013). Furthermore, there was a positive correlation on the ADHD checklists and a questionnaire assessing internalizing problems, indicating that depression, anxiety, and stress were associated with higher ADHD scores.

Overall, findings show that ADHD is associated with marked impairment in multiple domains. Among college students, psychiatric comorbidity extends to include depression, anxiety and poor self-esteem, which may further compromise academic functioning among this group.

Obesity

A brief overview of the biological mechanisms involved in food intake and weight, specifically overweight and obesity will be explored. Obesity is excessive body fat, which is measured through the Body Mass Index (BMI) (Friedman, 2009). BMI is calculated using the formula: weight (kg) / height $(m)^2$. For adults, the resultant BMI is categorized into on the following four categories: BMI < 18.5 = underweight; BMI 18.5 – 24.9 = typical; BMI 25 – 29.9 = overweight; and BMI of 30 and greater is considered obese (CDC, 2017). In the adult U.S population, between the time periods of 1976–1980 and 1999–2000 the occurrence of obesity has increased by 110% from 14.5% to 30.5% and the occurrence of overweight has increased by 40% from 46.0% to 64.5% (Stein & Colditz, 2004). Currently, about 65% of adults are overweight/obese and 15% of children, age 6 to 19, are overweight.

Excessive weight may stem from an inability to consciously control one's eating habits, but evidence suggests that the balance between energy intake and output is mostly controlled by one's biological system (Friedman, 2009). Even when one may consciously control their diet or increase they physical activities, which may reduce body fat, there are biological factors that intervene and create an instinctive impulse to consume more food until they return to their original weight (Friedman, 2009). It has even been found that the heritability of a genetic predisposition for obesity ranges from 70% to 80% (Friedman, 2009). The influence of heredity is seen in adoption studies where the weight of children resembles their biological parents more than their adoptive parents. Mutations in genes - generally those that control energy balance - have also been known to cause obesity. The hormone leptin, which is produced from adipocytes (white fat cells), is involved in the management of body weight. Leptin acts on many systems, including the brain centers that control food intake and energy outflow (Friedman, 2009). The

leptin receptors are found in the hypothalamus of the brain, and injuries to this region can result in obesity (Friedman, 2009). The hypothalamus regulates homeostatic processes of the body, including intake, expenditure and storage of calories. The feedback loop is also involved in food intake and weight by signals sent from the brain to other parts of the body, including adipose tissue, gastrointestinal tract and pancreas (Friedman, 2009). Leptin, however, is not the only hormone that influences weight gain. Blood-borne and neural signals including metabolites control weight and energy on a more short-term basis by regulating food consumption (Friedman, 2009). These include glucose, and probably amino acids and fatty acids, as well as digestive hormones, including ghrelin and intestinal peptides such as GLP-1, peptide YY, cholecystokinin, bombesin and amylin (Friedman, 2009). A number of other factors influence body weight, including genetic, hormonal, behavioral, environmental and social factors.

Obesity and Impairments

Overweight and obesity are associated with increased risk of negative physical and internalizing outcomes, including poorer health consequences, and greater body dissatisfaction and stigmatization. In the psychosocial realm, overweight/obesity increases risk for internalizing problems, including depression, anxiety, and stress, and it has a negative impact on self-concept (Harriger & Thompson, 2012; Gariepy et al., 2009).

Using data across three studies, Robinson, Sutin, and Daly (2016) examined the associations among obesity, perceived weight discrimination, and depression. Perceived weight discrimination is the stigmatization and biased treatment individuals face based on their weight. Robinson et al. (2016) analyzed three studies of U.S and U.K adults to analyze the relation between obesity and perceived weight discrimination, and in turn, its effect on depressive symptoms. Study 1 used data from the English Longitudinal Study for Ageing (ELSA) to

determine whether there was a relation between obesity and depression in English adults of ages greater than or equal to 50 years. Study 2 used data from the Health and Retirement Study (HRS) to replicate the results from Study 1 in a sample of Americans of ages 50 and above, and their spouses. Study 3 obtained data from Midlife in the United States (MIDUS) study and sought to replicate the findings of Studies 1 and 2, but with a more varied age range of 25-74 years. The BMIs of participants were recorded by trained nurses and measured in kg/m^2 and categorized into one of the following categories for all three studies: normal weight (BMI<25), overweight (BMI 25-29.9), Class 1 (BMI 30-34.9), Class 2 (BMI 35-39.9), and Class 3 obesity (BMI 40 and above) (Robinson et al., 2016). All three studies required participants to complete an adapted version of the Perceived Everyday Experiences with Discrimination Scale and they each assessed depressive symptoms. All three studies provided the same results: Participants in the Class 2 and 3 obesity categories were more likely to develop depressive symptoms over the years. The three studies also concluded that higher levels of perceived weight discrimination were in part responsible for greater depression in adults with obesity. On average, this perceived weight discrimination was shown to be responsible for 31% of the depressive symptoms in Class 2 and Class 3 obesity (Robinson et al., 2016). How weight discrimination increased risk for depression is unclear, but weight discrimination often leads to poor self-image and low self-esteem, which may in turn, increase one's risk of depression.

The relation between obesity and internalizing problems, specifically anxiety, has been the subject of a meta-analysis of 16 studies (Gariepy, Nitka & Schmitz, 2009). According to the DSM-5, an anxiety disorder is characterized by excessive worrying and anxiety that are difficult to control and leads to impairments in everyday life and events (APA, 2013). Impairments affect the person's occupational, social, and academic performance. Gariepy et al. (2009) assert that

obesity may lead to anxiety disorders through different mechanisms, including weight-related discrimination and health-related problems, which can both be distressing for an individual. However, findings linking obesity and anxiety disorders are not clear since the results are contradictory across studies. There is also the consideration of demographic factors, which may influence the effects obesity has on individuals' lives, such as obesity being more likely to cause anxiety in females than males. Obesity often results in poor social support and poor health, the stress of which can result in anxiety disorders (Gariepy et al., 2009). The results suggest that there is a weak but positive association between obesity and anxiety disorders, with more than half of the studies supporting this claim. The evidence suggested that there is a stronger association between anxiety disorders and severe obesity (BMI≥35) than there is for moderate obesity (BMI 30-35) (Gariepy et al., 2009). In the end, the study concluded that while there is an association between anxiety disorders and obesity, the evidence to support this is only moderate and requires more extensive studying (Gariepy et al., 2009).

Zhao et al. (2008) examined the association between depression and anxiety and BMI with consideration for obesity-related comorbidities (ORCs) and psychological and lifestyle influences. The sample was very large, comprising 177,047 participants of ages 18 and older covering a wide demographic, that included age, sex, race, education, employment, relationship status, and other lifestyle choices. Participants self-reported weight and height for BMI calculations (Zhao et al., 2008). Participants were assessed by the Patient Health Questionnaire-8 (PHQ-8) and reported diagnoses of depression and anxiety. Both males and females who were underweight, overweight, or obese, were significantly more likely to have psychiatric disorders than those with normal weight. However, women, regardless of their condition, had a higher frequency of depression than men of equal status (Zhao et al., 2008). After adjustments for

demographical factors such as smoking, drinking, emotional support, physical activities, and so on, it was found that men whose weights resided on the extreme opposite ends of the scale, with BMIs >= 40kg/m^2 or <18kg/m^2 were significantly more likely to have depression than men of a normal BMI (Zhao et al., 2008). These same demographic factors for women showed only women who were overweight or obese in any capacity had a significantly increased risk of depression over women with a normal BMI (Zhao et al., 2008). These findings contributed to Zhao et al. (2008) view that BMI is an independent predictor of mental ill health.

Obesity has also been shown to negatively affect mental health in adolescent populations. Erermis and colleagues (2004) examined the type and frequency of psychopathology; specifically depression, anxiety and self-esteem as it relates to obesity in a sample of adolescents aged 12-16. Based on BMI, three groups were generated, clinical obese (seeking treatment from endocrinology outpatient clinic), non-clinical obese (age and sex-matched to clinical group), and a normal weight control group (sex-matched and of same age range) with 30 individuals in each. Measures included the Child Behavior Checklist (CBCL) completed by a parent, and the Children Depression Inventory (CDI) and Rosenberg Self-esteem Scale (SES), which were self-reported. Based on the results, the clinical obese group showed higher mean scores of anxiety-depression, social problems, social withdrawal, internalizing behavior, externalizing behaviors, and total problems compared to the non-clinical obese and normal weight group (Erermis et al., 2004). Also, the non-clinical obese group exhibited greater average scores of social problems, internalizing behavior, and total problems compared to the normal weight group. Statistically, there was no significant difference in depression scores between the two obese groups, even though the mean scores for these groups were greater than the control group (Erermis et al., 2004). Similar findings were obtained for self-esteem, with the clinical obese group displaying

significantly lower self-esteem than the non-clinical obese group. Gender effects were also seen, with males showing lower self-esteem levels than females. The frequency of mental illness was significantly higher in the clinical obese and non-clinical obese groups compared to the normal weight group. The clinical obese group evidenced a higher prevalence of major depressive disorder compared to the other groups, while no difference in rates of anxiety disorder were seen (Erermis et al., 2004). Overall, this study found that clinically obese adolescents possessed more behavioral and emotional problems and exhibit greater psychopathology compared to the non-clinically obese and the normal weight adolescents. Although not all obese adolescents evidenced negative outcomes, the study provides support that obesity is related to psychopathology.

ADHD and Obesity

Over the past 10 years, ADHD has been hypothesized to increase risk for obesity, and preliminary studies are providing evidence to support this claim. Cortese et al. (2013) conducted a 33-year follow-up study analyzing BMI and obesity in men with and without a history of childhood ADHD. Previous data reported higher obesity in children with ADHD, men with childhood ADHD and in adults with persistent ADHD (Anderson, Cohen, Naumova, & Must, 2006). Cortese et al.'s (2013) participants were 207 white males who were recruited at a mean age of 8.3 years and diagnosed with ADHD. Participants were followed up at 41 years of age. The control group consisted of 178 white males who were recruited at 18 years of age and who had never experienced any ADHD in childhood. They were matched with the ADHD group on age, parental social class and geographic residence. At age 41, 111 subjects from each group self-reported height and weight to calculate BMI and they also completed a psychiatric assessment. Men with childhood ADHD showed significantly higher BMI, weight and obesity

compared to men without childhood ADHD, and similar results were shown after adjustment for parental SES and psychiatric disorders (Cortese et al., 2013). Based on these results, adults with childhood ADHD are at risk of obesity later in life (Cortese et al., 2013). Individuals with ADHD face greater risk of emergent overweight and obesity later in adulthood. Possible explanations of the association between ADHD and obesity are neuropsychological deficits of inhibitory control, delay aversion, and poor planning and monitoring of eating patterns and behaviors (Cortese et al., 2013). Increased food and calorie intake may lead the body to store excessive fat and weight, leading to high BMI, overweight and obesity.

Hanć (2018) reviewed studies on the relation between ADHD and an increased risk of obesity. Requirements for the review were studies published between 2004-2016 that examined the relation between ADHD and obesity; 31 studies were found. Factors of socioeconomic status, age, sex, pharmacological treatment, and comorbid conditions were examined in each study. For those with ADHD, the prevalence rate was 20.38% for overweight and 15.45% for obesity; compared to the control group's prevalence rates of 17.02% and 11.70%, respectively (Hanć, 2018). Even though many studies controlled for variables such as age, sex, socio-economic status, ethnicity, the association between ADHD and obesity was still significant.

Pagoto et al. (2009) investigated the association between ADHD and overweight and obesity in the US population using a sample of 6,735 adults of ages 18-44. Also, examined was the involvement of depression, and binge eating disorder in an adult population. Data completed by US adults from the Collaborative Psychiatric Epidemiology Studies (CPES) was used, which included three surveys observing mental disorders based on standardized diagnostic criteria (Pagoto et al., 2009). Measures included BMI, Diagnostic Interview Schedule for DSM-IV to assess childhood ADHD, and to assess adult ADHD the Adult ADHD Clinical Diagnostic Scale,

ADHD Rating Scale and ADHD Rating Scale was used. A subsample of participants were interviewed by clinical interviewers and diagnosed with adult ADHD. Depression and binge eating disorder was diagnosed based on the DSM-IV criteria using the Composite International Diagnostic Interview. Participants were grouped by meeting no ADHD criteria, only childhood ADHD criteria, and those who met both childhood and adulthood ADHD criteria (Pagoto et al., 2009). Results found that those with adult ADHD showed significant greater likelihood of being overweight or obese, while childhood ADHD showed no such connection. Among individuals with adult ADHD, overweight and obesity rates were 33.9 and 29.4%, compared to rates of 28.8 and 21.6% for those with no ADHD, respectively (Pagoto et al., 2009). Independently, ADHD was found to be associated with depression, and obesity was found to be associated with depression. Controlling for depression did not affect the association between ADHD and obesity, and when controlling for ADHD, binge eating disorder was associated with obesity not overweight (Pagoto et al., 2009). Findings suggest that ADHD and overweight/obesity are associated. ADHD and obesity are linked to hypo-dopaminergic function involving the prefrontal cortex, which is responsible for sustaining and dividing attention, and inhibition (Levitan et al., 2004).

Present Study

Based on the literature review, many studies looked at ADHD, obesity and internalizing factors, however findings were inconsistent. Also, there has been limited work concentrating on college students and those in a non-clinical population, where they are not diagnosed with ADHD, but exhibit ADHD-like symptoms. The present study will add to the literature by encompassing on all three variables of ADHD, obesity and internalizing problems, in a young adults college sample.

The aim of this study was to investigate whether higher ADHD symptoms and higher BMI are associated with internalizing impairments of depression, anxiety, stress and self-esteem. It is predicted that higher ADHD symptoms and higher BMI are positively associated. It is also hypothesized that higher ADHD symptoms are associated with greater depression, anxiety, stress and lower self-esteem. Also hypothesized is that higher BMI is associated with greater depression, anxiety, stress and lower self-esteem. Finally, it is hypothesized that BMI moderates the association between ADHD and internalizing problems, such that those with both higher ADHD symptoms and higher BMI will have the greatest internalizing problems (i.e., most severe depression, anxiety, stress and lowest self-esteem) compared to other groups.

Method

Participants

Students (N=708) from The City College of New York, CUNY were recruited through an online platform of The City College of New York Psychology Department called the SONA system, which is used to manage participant sign-up for experiments. Inclusion criteria included age range of 18- 35 years, fluency in English and part time or full-time enrollment as undergraduate students at The City College of New York. Exclusion criteria included: taking medication for ADHD or having had taken medication for ADHD in the past three months; currently taking or history of taking psychotropic medication; a history of neurological or major psychiatric disorder; and current or history of smoking in the past three months. Students who met exclusion criteria were not permitted to continue taking the survey and were exited out of the questionnaire following a “Thank you” message.

Of the 708 undergraduate students, 597 (84.3%) met inclusion criteria and 108 (15.3%) students were ineligible to participate in the study. A further three (.4%) students consented to participate, but then did not complete any screening questions. These participants were considered to have withdrawn from the study. Of the 108 ineligible participants, 17 (15.7%) had taken ADHD medication in the past three months; 28 (25.9%) were currently taking psychotropic medication or had a history of doing so; 48 (44.4%) were smokers who had a history of smoking in the past three months; and 18 (16.7%) had a history of a neurological or major psychiatric disorder. Multiple ineligible participants met more than one exclusion criterion.

Fifteen of the 597 eligible participants did not self-report their height and/or weight, thus BMI was not calculated. Two participants did not complete the ADHD severity measure, and therefore could not be classified as Low/High Risk for ADHD. The final sample was N=580.

Of the 580 individuals eligible for the study, the mean (SD) age was 20.68 (3.10) with 70.7% (n=410) of participants identifying as female and 39.3% (n=228) identifying their ethnicity as Latinx. The sample was racially diverse: 29.7% (n= 172) identified as Asian; 23.8% (n= 138) as Black/African American; 29.1% as white (n=169) and 17.4% (n= 101) identified as belonging to a different racial group or as bi- or multiracial. The majority of participants (63.1%, n=366) reported a household income below $40,000. According to the U.S Census Bureau, from 2014 to 2018 the median household income in New York City was $60,762, therefore many participants were from socially disadvantaged households ("U.S. Census Bureau: New York city, New York").

Based on BMI and ADHD severity, n=580 participants were classified into one of four mutually exclusive groups. The control group (Underweight or Typical BMI/ADHD severity

<1SD above the mean) had 286 (47.9%) participants. The high BMI group was n=151 (25.3%) and comprised individuals with Overweight or Obese BMI and ADHD severity <1SD above the mean. There were 93 (15.6%) participants in the High ADHD group; that is, Underweight or Typical BMI and ADHD severity >=1SD above the mean. Finally, the Comorbid group (i.e., Overweight/Obese BMI and ADHD severity >=1SD above the mean) had 50 (8.4%) participants. Demographics are displayed in Table 1.

Table 1. *Key variables on a function of group.*

Variable	Total	Controls (1)	Overweight / Obese only (2)	ADHD only (3)	Comorbid (4)	F	df	*p*	η_p^2
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)				
Age (yrs)	20.68 (3.10)	20.46 (2.88)	21.18 (3.63)	20.40 (2.34)	20.91 (3.70)	2.13	3, 573	.10	.01
Height (in)	65.15 (3.95)	65.38 (3.93)	64.63 (3.76)	65.67 (3.69)	64.43 (4.88)	2.28	3, 576	.08	.01
Weight (lbs)	145.25 (32.96)	130.05 (21.32)	172.30 (29.86)	131.21 (20.56)	176.68 (41.02)	121.98	3, 576	<.0001 1=3< 2=4	.39
BMI	24.00 (4.62)	21.30 (2.14)	28.87 (3.33)	21.33 (2.27)	29.67 (4.45)	345.28	3, 576	<.0001 1=3< 2=4	.64
ADHD Severity*	19.52 (5.58)	16.98 (3.26)	17.18 (3.32)	26.71 (3.77)	27.82 (4.74)	295.96	3, 576	<.0001 1=2< 3=4	.61

	N (%)	N (%)	N (%)	N (%)	N (%)	χ^2	df	*p*	V
Gender						1.26	3	.74	.05
Male	170 (100)	79 (46.5)	46 (27.1)	31 (18.2)	14 (8.2)				
Female	410 (100)	207 (50.5)	105 (25.6)	62 (15.1)	36 (8.8)				
Ethnicity						6.61	3	.09	.11
Latinx	228 (100)	107 (46.9)	70 (30.7)	29 (12.7)	22 (9.6)				
Not Latinx	352 (100)	179 (50.9)	81 (23.0)	64 (18.2)	28 (8.0)				
Race						23.81	15	.07	.13
Native American or Native Alaskan	11 (100)	7 (63.6)	2 (18.2)	1 (9.1)	1 (9.1)				
Asian	172 (100)	96 (55.8)	31 (18.0)	31 (18.0)	14 (8.1)				
Black/ African American	138 (100)	51 (37.0)	47 (34.1)	26 (18.8)	14 (10.1)				

White	68 (100)	38 (55.9)	19 (27.9)	8 (11.8)	3 (4.4)				
Native Hawaiian or Pacific Islander	2 (100)	1 (50)	0 (0)	1 (50)	0 (0)				
Other	101 (100)	53 (52.5)	29 (28.7)	10 (9.9)	9 (8.9)				
Income						9.41	15	.86	.07
<10,000	77 (100)	38 (49.4)	26 (33.8)	9 (11.7)	4 (5.2)				
10,000-24,999	169 (100)	86 (50.9)	41 (24.3)	26 (15.4)	16 (9.5)				
25,000-39,999	120 (100)	56 (46.7)	34 (28.3)	18 (15)	12 (10)				
40,000-69,999	110 (100)	54 (49.1)	26 (23.6)	21 (19.1)	9 (8.2)				
70,000-99,999	44 (100)	19 (43.2)	13 (29.5)	7 (15.9)	5 (11.4)				
>=100,000	60 (100)	33 (55)	11 (18.3)	12 (20)	4 (6.7)				

*Measured using Barkley Deficit in Executive Functioning Scale ADHD Index

Measures

Demographics Form

The demographics form collected self-reported information from the participant about their age, gender, ethnicity, race and household income.

Body Mass Index (BMI)

BMI is a measure of body fat that is determined from a person's height and weight. BMI was calculated based on participant's self-reported height (in inches) and weight (in pounds). Imperial measures were converted to metric using the following formula:

Height (m) = Height (inches) / 39.3701

Weight (kg) = weight (lbs) x 0.4546

Participants' body mass index was calculated by weight (kg) / height $(m)^2$ (CDC, 2017). Individuals were then classified into the following BMI categories: Underweight = BMI<18.5, Normal = BMI 18.5–24.9, Overweight = 25.0–29.9, and Obese= BMI ≥30 (CDC, 2017).

Barkley Deficits Executive Functioning Scale (BDEFS) (Barkley, 2011)

This scale assesses thoughts and behaviors that represent those of executive functioning deficits in relation to ADHD symptoms. This study used the 11 ADHD-EF Index items from the Long form designed for adults of 18-34 years of age. This scale measures behaviors characteristic of ADHD among participants. Participants indicated how frequently the behaviors occurred in the last six months. Scores are recorded on a four-point Likert scale: "never or rarely," "sometimes," "often," and "very often." A total score was obtained on an ADHD Index, which was used to determine the individuals who had higher ADHD symptoms. Scores greater than or equal to 1SD (≥1SD) above the mean by age- and sex-norms were classified as High

ADHD. This scale has been shown to be reliable and valid. In this study, internal consistency was α =.83. A copy of this instrument is not appended due to Copyright protections.

Rosenberg Self-Esteem Scale (Rosenberg, 1965).

This scale assessed self-esteem, which are feelings about oneself, self-worth and self-acceptance. This questionnaire addresses general feelings about oneself. The questionnaire comprises 10-items and responses were recorded on a four-point Likert scale of Strongly Agree, Agree, Disagree and Strongly Disagree. For scoring, items 1, 2, 4, 6, and 7 are scored as 0: strongly disagree to 3: strongly agree and items 2, 5, 6, 8, 9 are reverse scored as 0: strongly agree to 3: strongly disagree. All 10 items are summed to get a total score (Rosenberg, 1965). In this study, the higher scores represented lower self-esteem. Total scores were also dichotomized to reflect Low and High self-esteem based on scores of 0 to 15 reflected high self-esteem and scores of 15 to 30 reflected low self-esteem. The Rosenberg Self-Esteem Scale has high reliability and internal consistency of 0.77 (Rosenberg, 1965). In the current data set, internal consistency is α =.94 (see Appendix A).

Depression Anxiety and Stress Scale (DASS 21) (Lovibond & Lovibond, 1995)

The DASS is a 21-item questionnaire that measures an individual's emotional state with respect to the three subscales of depression, anxiety and stress. Each subscale contains seven items. The subscale of stress includes items 1, 6, 8, 11, 12, 14, and 18, anxiety includes items 2, 4, 7, 9, 15, 19 and 20, and depression includes items 3, 5, 10, 13, 16, 17, and 21. Responses reflected symptoms over the past week. Scores were recorded on a four-point Likert scale of 0: did not apply to me at all, 1: applied to me to some degree, or some of the time, 2: applied to me to a considerable degree or a good part of time and 3: applied to me very much or most of the time. Scores for each subscales, depression, anxiety and stress, were calculated by summing

related items. Scores were multiplied by two, in order to compare scores to the fixed DASS scoring scales (Lovibond & Lovibond, 1995). After scoring, participants were placed into categories of normal, mild, moderate, severe or extremely severe depending on severity level for each subset. For depression, scores were categorized as normal: 0-9, mild: 10-13, moderate: 14-20, severe: 21-27, and extremely severe: 28+. For anxiety, scores were categorized as normal: 0-7, mild: 8-9, moderate: 10-14, severe: 15-19, and extremely severe: 20+. For stress, scores were categorized as normal: 0-14, mild: 15-18, moderate: 19-25, severe: 26-33, and extremely severe: 34+ (Lovibond & Lovibond, 1995). In this study, total scores were also dichotomized to reflect Low and High symptoms/ impairments for each subscale. Categories of normal and mild reflected low depression, anxiety or stress, while scores categorized as moderate, severe and extremely severe were considered to represent high depression, anxiety or stress. Internal consistency for this sample is α =.90 (see Appendix B).

Procedure

Students who signed up agreed to proceed to the consenting procedure, where they received information about the study and agreed to participate in the study. After consenting, seven screening questions were completed to determine if the participant was eligible. Students who met inclusion criteria continued to complete the online assessment of questionnaires that measured demographics, self-reported height and weight, attention, hyperactivity and impulsivity, self-esteem, functional impairment and emotional functioning. All questionnaires were based on self-reported data. The online questionnaires took approximately one hour to complete. Questionnaires were completed electronically at the participant's time and convenience. Participants were able to exit out of the survey at any time without repercussion. All participants received one SONA credit for taking part (even if surveys were not completed or

they were excluded after screening), which could complete a Psychology course research option or could earn extra credit. The City University of New York Integrated Institutional Review Board approved this study.

Missing Data

As noted above, 17 (2.8%) participants did not provide information to calculate either BMI or ADHD group status. For missing BMI and ADHD group data, an independent t-test was used for continuous data of age, height and weight, while a chi-square was used for categorical data of gender, ethnicity, race and income. Individuals who were missing data on the ADHD severity and/or BMI did not differ in age, gender, ethnicity, race and household income (all p values $\geq .09$).

Data Analysis

Data was analyzed using SPSS version 25. Participants' demographic factors (self-reported gender, ethnicity, race, and income) and key anthropometric (height (in), weight (lbs), BMI), and ADHD severity were analyzed first. Body mass index (BMI) was calculated based on the participant's self-reported height and weight, following which participants were classified into four categories: Underweight (BMI < 18.5), Normal/Typical (BMI =18.5 to 24.9), Overweight (BMI=25.0 to 29.9), and Obese (BMI ≥ 30) (CDC, 2017). Two BMI categories were combined to make binary categories, Underweight/Normal (coded as 0) were classified together and Overweight and Obese (coded as 1) were classified together. For ADHD severity, participants who scored ≥1SD above the normative mean were considered to have higher ADHD symptoms, and therefore classified into the High ADHD group, while participants whose ADHD severity score was less than 1SD above the mean were classified as Low ADHD. To examine the association between ADHD and BMI, a chi-square analysis was carried out.

Participants were grouped based on the BMI and ADHD severity. Individuals categorized as Underweight/Typical BMI and Low ADHD severity were placed into the Control group; the High BMI only group consisted of those Overweight/Obese BMI and ADHD severity <1SD above the mean; High ADHD only group were those Underweight/Typical BMI and ADHD severity ≥1SD above the mean; and Comorbid group were those with Overweight/Obese BMI and ADHD severity ≥1SD above the mean.

Data for internalizing factors of depression, anxiety, stress and self-esteem were checked for normality. Due to internalizing factors not being normally distributed, medians were reported and binary categories of impairments were created. The binary dependent variables of depression, anxiety and stress were classified as Normal/Mild (coded as 0) and Moderate to Extremely Severe (coded as 1), while self- esteem was classified as Low (coded as 0) and High (coded as 1). Descriptive statistics were collected for internalizing impairments. A Spearman rho correlation coefficient was used to examine if internalizing factors were associated. To analyze associations among ADHD and internalizing factors, and BMI and internalizing factors, a chi-square was used. A binary logistic regression was used to examine interactions of ADHD, BMI and internalizing factors of depression, anxiety, stress and self-esteem.

Results

ADHD and Demographic Factors

Gender was not associated with ADHD status, as shown by a non-significant chi-square test,χ^2 (1, N = 585) = .37, p = .55. Nearly three quarters (71.6%) of the Low ADHD group were females, compared to 69% of the High ADHD group. Similarly, ethnicity was not related to ADHD status, χ^2 (1, N = 585) = 1.39, p = .24. Of those in the Low ADHD group, 40.7% identified as Latinx, compared to 35.2% of the High ADHD group. A chi-square was also

performed to examine the relation between race and who were more likely to have elevated ADHD scores. Again, the results were not statistically significant, χ^2 (5, N = 497) = 7.54, p = .18. Among those with High ADHD, 1.7% were Native American/Native Alaskan; 39.2% were Asian; 33.3% were Black/African American; 9.2% were White; 0.8% were Hawaiian/Pacific Islander; and 15.8% identified as belong to a different race, biracial or multiracial. Among those with Low ADHD, 2.4% were Native American/Native Alaskan; 33.7% were Asian; 26.3% were Black/African American; 15.1% were White; 0.3% were Hawaiian/Pacific Islander; and 22.3% identified as belong to a different race, biracial or multiracial. Finally, household income was not associated with ADHD status. Individuals with lower household income (≤ $69,999.99/year) were not more likely to be in the High ADHD symptoms group (24.2%) than individuals with higher household income (≥$70,000/year) (27.4%), χ^2 (1, N = 585) = .46, p = .50.

BMI and Demographic Factors

Gender was not associated with BMI classification,χ^2 (1, N = 582) = .06, p = .81; 71.1% of the Low BMI group were females compared to 70.1% of the High BMI group. A significant chi-square showed there to be an association between ethnicity and BMI, χ^2 (1, N = 582) = 5.31, p = .02. Students who identified as not Latinx were more likely to be in the High BMI group (45.8%) than the Low BMI group (36.0%). Differences in BMI classification as a function of race were also found,χ^2 (5, N = 494) = 12.85, p = .025. with students identifying as Asian more likely to be in the Low BMI group than students identifying as Black/African American (p=.001) or Biracial/Multiracial (p=.04). No other group differences were found (all p > .05). Frequencies by group for High BMI are: Native American/Native Alaskan, 1.8%; Asian, 26.6%; Black/African American, 36.1%; White, 13%; Hawaiian/Pacific Islander, 0.6%; and Biracial/multiracial, 19.4%. Frequencies by group for Low BMI are: Native American/Native

Alaskan, 2.5%; Asian, 39.4%; Black/African American, 24.0%; White, 14.2%; Hawaiian/Pacific Islander, 0%; and Biracial/multiracial, 22.5%). Individuals with lower household income (≤ $69,999.99) were not more likely to have a High BMI (35.1%) than individuals with a higher household income (≥$70,000.00/year) (31.7%), $\chi^2(1, N = 582) = .44, p = .51$.

ADHD and BMI

Across the whole sample, mean (SD) ADHD severity was 19.52 (5.58), while mean (SD) BMI was 24 (4.62). A Pearson correlation between ADHD severity and BMI was $r = .07$, $p = .09$. Of 580 participants, 143 (24.7%) reported higher scores on the Barkley Deficit in Executive Functioning Scale ADHD Index (≥1SD above the mean) and 437 (75.3%) reported lower scores on the ADHD index (<1SD above the mean). Among participants who were High ADHD, 50 (35%) students were classified as Overweight/Obese BMI, while 93 (65%) were Underweight/Typical BMI. Among participants who were Low ADHD, 151 (34.6%) were categorized as Overweight/Obese BMI, while 286 (65.4%) were Underweight/Typical BMI. A chi-square was performed to determine whether individuals who had elevated ADHD scores were more likely to have a High BMI (i.e., Overweight/Obese BMI). The results were not statistically significant, $\chi^2(1, N = 580) = .008, p = .929$.

Internalizing Factors

For depression, anxiety and stress, the scale ranged from 0 to 42. Across the whole sample, median (interquartile range) for depression was 6 (2-14), anxiety 8 (2-14), and stress 8 (4-14). Self-esteem had a range from 0 to 29 with a median (interquartile range) of 11 (6-15). See Figure 1 for median severity of internalizing problems as a function of Group status.

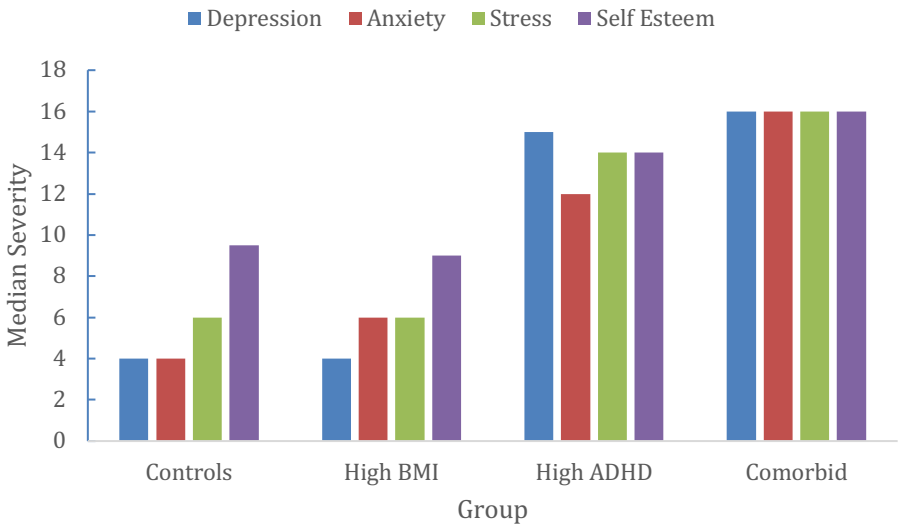

Figure 1. Median severity of internalizing problems as a function of Group (Controls, High BMI, High ADHD, and Comorbid).

A Spearman rho correlation coefficient was conducted to assess the association among the internalizing factors of depression, anxiety, stress and self-esteem. Results indicated that there were significant moderate associations between depression and anxiety, r_s (566) = .48, p < .0001, depression and stress, r_s (566) = .42, p < .0001, and depression and self-esteem, r_s (565) = -.48, p < .0001. Anxiety was also moderately associated with stress, r_s (566) = .41, p < .0001, and weakly associated with self-esteem r_s (565) = -.27, p < .0001. In addition to its significant associations with depression and anxiety, stress was also associated with self-esteem, r_s (565) = -.39, p < .0001).

When individuals were classified as falling into Low or High groups for the internalizing problems, a significant minority fell into the High groups for each outcome (see Table 2). For the whole sample, over one quarter of participants (26.9%) were classified as High Depression, after self-reporting depressive behaviors that were in the Moderate to Extremely Severe range. Nearly three quarters (73.1%) of participants had Low Depression; that is, their scores fell in the Normal to Mild range. Anxiety levels were generally higher, with 39.7% classified as High

Anxiety as their self-reported anxiety fell in the Moderate to Extremely Severe range. In contrast, 60.3% had total Anxiety scores in the Normal to Mild range and thus were classified as Low Anxiety. Regarding stress, 12.5% of participants were classified as High Stress (i.e., self-reported stress scores in the Moderate to Extremely Severe range) compared 87.5% classified as Low Stress (i.e., total Stress in the Normal to Mild range). Nearly one fifth (17.5%) of participants reported experiencing Low self- esteem, while 82.5% participants reported High levels of self-esteem. For frequency of participants per group for each internalizing factor, see Table 2.

Table 2. *Internalizing problems as a function of Group status.*

Internalizing Factors	Total[a]	Control (1)	Overweight/ Obese only (2)	ADHD only (3)	Comorbid (4)	χ^2	df	*p*	*V*
	N (%)	N (%)	N (%)	N (%)	N (%)				
Depression						110.52	3	.0001	.44
Low	411 (100)	232 (56.4)	126 (30.7)	37 (9)	16 (3.9)			1=2< 3=4	
High	151 (100)	48 (31.8)	19 (12.6)	55 (36.4)	29 (19.2)				
Anxiety						65.35	3	.0001	.34
Low	339 (100)	200 (59)	93 (27.4)	39 (11.5)	7 (2.1)			1=2< 3=4	
High	223 (100)	80 (35.9)	52 (23.3)	53 (23.8)	38 (17)				
Stress						41.14	3	.0001	.27
Low	492 (100)	261 (53)	132 (26.8)	69 (14)	30 (6.1)			1=2< 3=4	
High	70 (100)	19 (27.1)	13 (18.6)	23 (32.9)	15 (21.4)				
Self-esteem						85.39	3	.0001	.39
Low	98 (100)	26 (26.5)	13 (13.3)	36 (36.7)	23 (23.5)			1=2< 3=4	
High	463 (100)	254 (54.9)	131 (28.3)	56 (12.1)	22 (4.8)				

[a]Ns may differ due to missing data

Note. Depression, Anxiety, and Stress measured using the Depression, Anxiety and Stress Scale (Lovibond & Lovibond, 1995). Low Depression, Anxiety & Stress reflects self-reported scores falling in the Normal to Mild range. High Depression, Anxiety & Stress reflects self-reported scores falling in the Moderate to Extremely Severe range. Self-esteem was measured using the Rosenberg Self-Esteem scale (Rosenberg, 1965).

ADHD and Internalizing Factors

A series of chi-square analyses were conducted to examine the relations between ADHD status and the internalizing factors of depression, anxiety, stress and self-esteem. A significant association between ADHD and Depression was found, $\chi^2(1, N = 567) = 113.7, p < .0001$, with college students at high risk for ADHD more likely to fall into the High Depression group. Similar findings were obtained for the remaining outcomes. In all instances, participants in the High ADHD group were more likely to report experiencing High Anxiety, $\chi^2(1, N = 567) = 57.0, p < .0001$, High Stress, $\chi^2(1, N = 567) = 38.2, p < .0001$, and Low Self-Esteem, $\chi^2(1, N = 566) = 87.1, p < .0001$.

BMI and Internalizing Factors

Chi-square analyses were conducted to examine the relations between BMI and the internalizing factors of depression, anxiety, stress and self-esteem. BMI and anxiety were significantly related, $\chi^2(1, N = 562) = 7.1, p = .008$, suggesting that college students whose BMI is in the Overweight or Obese range are more likely to fall in the High Anxiety group. There were no significant associations between BMI and depression, $\chi^2(1, N = 562) = .38, p = .54$, stress, $\chi^2(1, N = 562) = 1.4, p = .25$, or self-esteem, $\chi^2(1, N = 561) = .5, p = .48$.

ADHD, BMI and Internalizing Factors

A series of binary logistic regression analyses were carried out to examine whether ADHD and BMI interacted to affect risk for elevated anxiety, depression, stress and low self-esteem (see Table 3).

Table 3.

Binary logistic regression analyses showing interaction of ADHD and BMI on internalizing outcomes depression, anxiety, stress and self-esteem.

Internalizing Outcome	Predictor	Chi Square (df)	B	SE	Odds Ratio	95% Confidence Interval
Depression	Constant		-1.58	.16	.21	
	ADHD		1.98	.27	7.19	4.27, 12.08
	BMI		-.32	.29	.73	.41, 1.29
	ADHD x BMI	102.4 (3)	.52	.48	1.67	.66, 4.26
Anxiety	Constant		-.92	.13	.40	
	ADHD		1.22	.25	3.40	2.09, 5.54
	BMI		.34	.22	1.40	.91, 2.14
	ADHD x BMI	66.4 (3)	1.05	.51	2.86	1.05, 7.78
Stress	Constant		-2.62	.24	.07	
	ADHD		1.52	.34	4.56	2.36, 8.89
	BMI		.30	.38	1.35	.65, 2.82
	ADHD x BMI	35.34 (3)	.10	.55	1.11	.38, 3.24
Self-esteem	Constant		-.04	.30	.96	
	ADHD		2.36	.42	10.54	4.66, 23.83
	BMI		.49	.37	1.63	.79, 3.34
	ADHD x BMI	73.83 (3)	-.52	.51	.60	.22, 1.63

For depression, binary logistic regression analyses revealed a significant chi square, χ^2 (3, N = 562) = 102.4, p < .0001, suggesting a significant model. Compared to individuals with Low ADHD, individuals with High ADHD were 7.19 times more likely to fall in the High (i.e., Moderate to Extremely Severe) depression group (95% CI [4.27, 12.08]). Individuals with Overweight/Obese BMI were no more likely to experience elevated depression than those with

Underweight/Typical BMI (OR=.73, 95% CI= .41, 1.30), and there was no significant BMI x ADHD interaction (OR= 1.67, 95% CI= .66, 4.26) (see Figure 2).

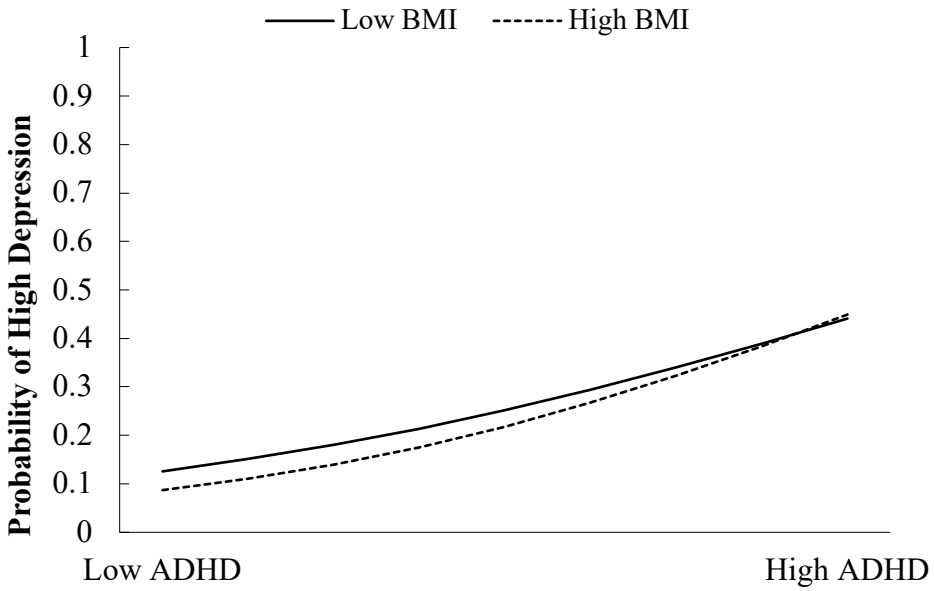

Figure 2. Interaction of BMI and ADHD on depression among college students.

For anxiety, a chi-square test indicated a significant model, $\chi^2(3, N = 562) = 66.4, p < .0001$. College students with High ADHD were 3.40 times more likely to be in the Moderate to Extremely Severe anxiety group than those with Low ADHD (95% CI [2.09, 5.54]). Individuals with Overweight/Obese BMI were no more likely to experience elevated anxiety than those with Underweight/Typical BMI (OR= 1.40, 95% CI= .91, 2.14). These main effects were qualified by a significant interaction of ADHD and BMI (OR= 2.86, 95% CI [1.05, 7.78]) (see Figure 3).

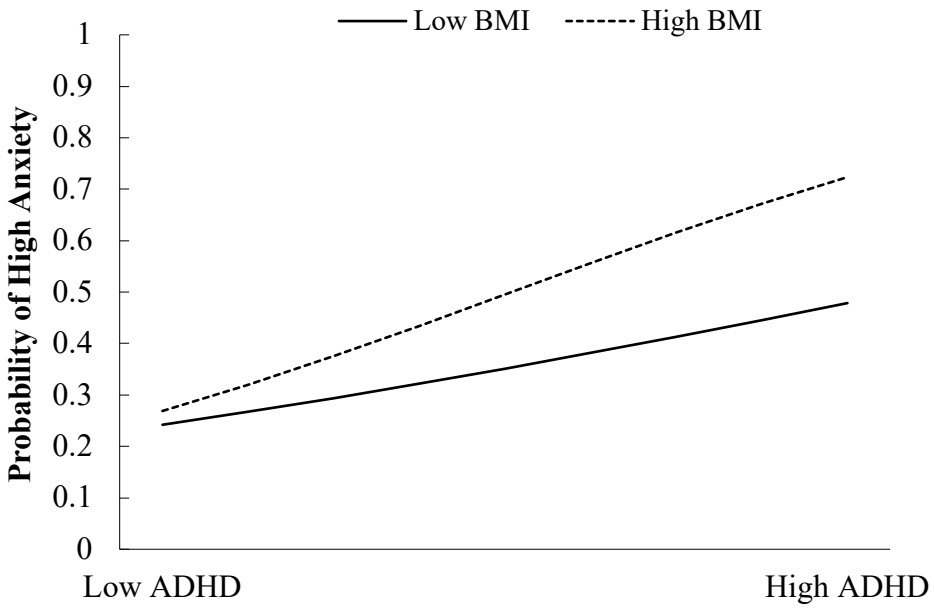

Figure 3. Interaction of BMI and ADHD on Anxiety among college students.

Follow up chi square analyses showed that for individuals with Low ADHD, individuals with High BMI were no more likely to be in the High Anxiety group than those with Low BMI, χ^2 (1, N = 425) = 2.37, p = .12. However, for those with High ADHD, individuals with High BMI were significantly more likely to be in the High Anxiety group than those with Low BMI, χ^2 (1, N = 137) = 9.76, p = .002. (see Figure 4).

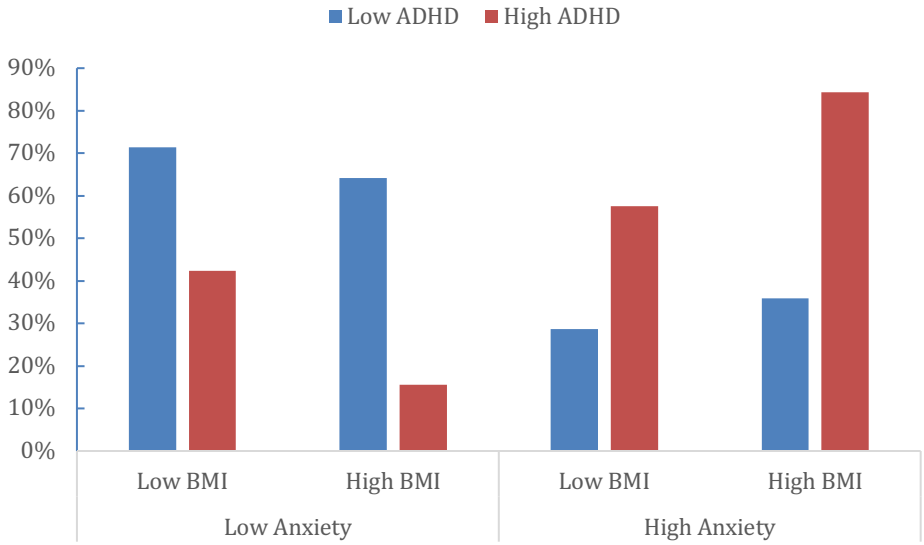

Figure 4. Percentage of individuals falling in the Low and High Anxiety groups as a function of BMI (Low, High) and ADHD (Low, High).

For the dependent variable stress, a chi-square test revealed a significant model, $\chi^2(3, N = 562) = 35.34$, $p < .0001$. Individuals with High ADHD are 4.58 times more likely to be in the High Stress group compared to individuals with Low ADHD (95% CI [2.36, 8.87]). College students with Overweight/Obese BMI were no more likely to experience elevated stress than those with Underweight/Typical BMI (OR= 1.35, 95% CI= .65, 2.82), and there was no significant BMI x ADHD interaction (OR= 1.11, 95% CI= .38, 3.24) (see Figure 5).

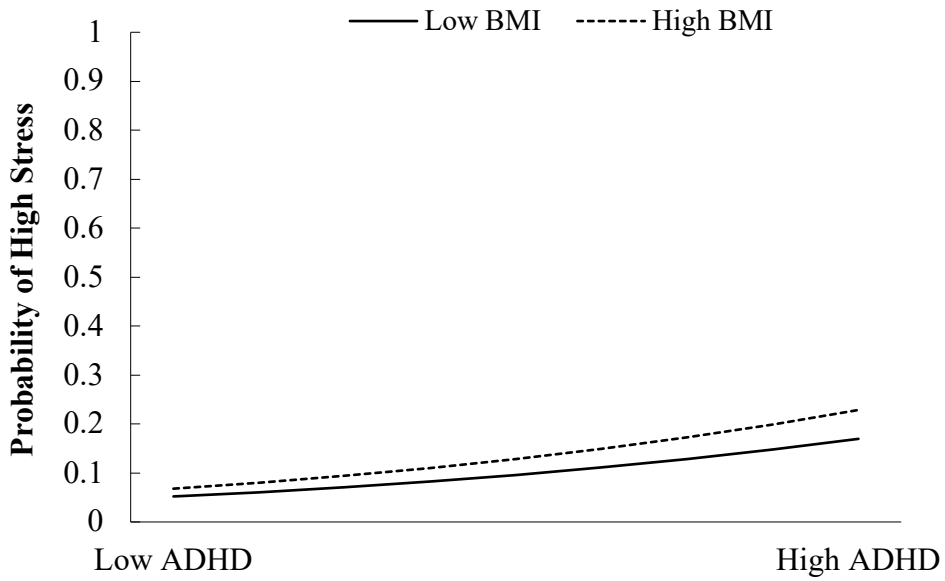

Figure 5. Interaction of BMI and ADHD on Stress among college students.

For self- esteem, a significant model was indicated by chi-square, $\chi^2(3, N = 561) = 73.83$, $p < .0001$. An odds ratio of 10.54, 95% CI [4.66, 23.83], suggested that college students with High ADHD are 10.54 times more likely to be in the Low self- esteem group, compared to individuals with Low ADHD. Individuals with Overweight/Obese BMI were no more likely to experience Low self-esteem than those with Underweight/Typical BMI (OR=1.63, 95% CI= .79, 3.34), and there was no significant BMI x ADHD interaction (OR= .60, 95% CI= .22, 1.63) (see Figure 6).

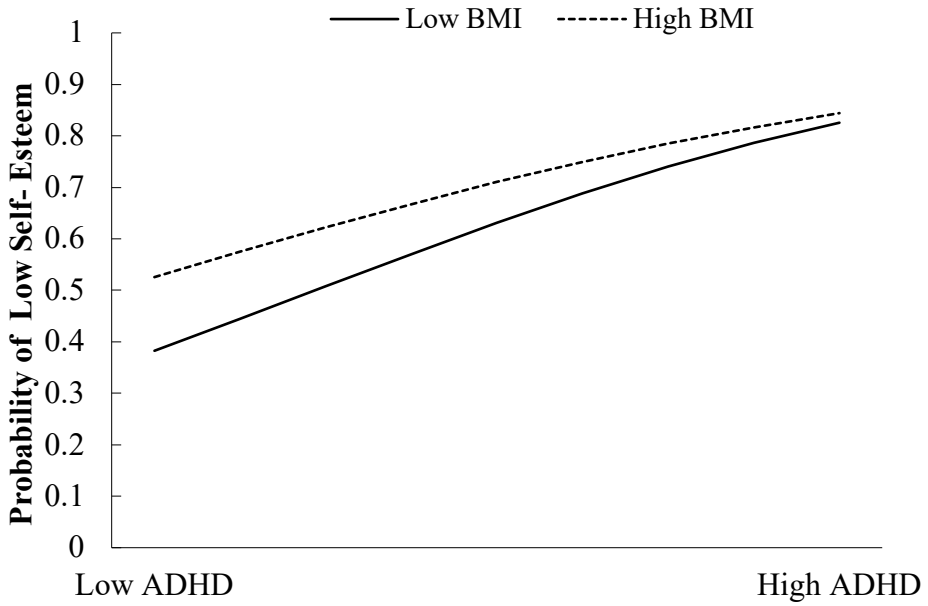

Figure 6. Interaction of BMI and ADHD on Self-Esteem among college students.

Discussion

This study examined whether overweight/obesity moderated the association between Attention Deficit Hyperactivity Disorder (ADHD) and internalizing problems, including depression, anxiety, stress and low self-esteem. Associations among these factors were investigated in a diverse, college student sample. Based on students' self-reported ADHD severity (using the ADHD-EF Index from the Barkley Deficits Executive Functioning Scale (BDEFS-LF; Barkley, 2011) and BMI (calculated from student's self- reported height and weight), no significant association between the constructs were seen. Furthermore, when participants were classified as Low/High ADHD and Low/High BMI, no association was seen in categorical analyses. Thus, the first hypothesis was not supported.

Although many studies have found an association between ADHD and obesity (Cortese et al., 2013; Hanć, 2018; Pagoto et al., 2009), this was not the case for our study. Similarly,

Cortese, Faraone, Bernardi, Wang, and Blanco (2013) also found no significant adult ADHD-BMI association in an epidemiologic study of 34,653 US adults. In Cortese et al.'s (2013) study, confounding variables (persistent ADHD, mood disorders, anxiety disorders, substance use disorders, ethnicity and income) were viewed as predictors of the outcome obesity. Cortese et al. (2013) found that individuals with Persistent ADHD (i.e., present in childhood and continues through to adulthood) showed greater rates of obesity in unadjusted analyses. However, this association was no longer observed when analyses controlled for socio-demographics and anxiety, depression, and substance use (Cortese et al., 2013). One methodological similarity between the present study and Cortese et al.'s (2013) study is that BMI was calculated from self-reported height and weight. Findings may differ when objective measures of height and weight are used.

Many factors besides ADHD symptoms may influence weight and obesity. One possibility is the societal movement of body positivity, which started to gain momentum in 2012. The body positivity movement involves breaking down unrealistic beauty beliefs in order to promote positivity, confidence, self-acceptance and self-love for your body and about the way you look (Cwynar-Horta, 2016; Cohen, Irwin, Newton-John, & Slater, 2019). This movement aims at positivity towards yourself and body regardless of weight, shape, size and appearance, and to overlook body shaming. Social media sites, such as Instagram™, are used as platforms to display body positive posts and images.

Other factors may influence obesity, including culture, ethnicity, social economic position (SEP) and behavioral factors. The prevalence of obesity is higher in non-whites; specifically, childhood obesity is greater in African Americans, Mexican Americans and Native American populations (Caprio et al., 2008). In the present study, Black/African American and

Biracial/Multiracial identifying individuals were more likely to be in the High BMI group than Asian-identifying participants. Social economic position (SEP) involves income, education, occupation and household resources (Caprio et al., 2008; Crawford, 2010). Studies have shown obesity is more prevalent in women from a SEP disadvantage. Obesity and SEP seem to have an inverse relationship, as obesity can lead to SEP and SEP can lead to obesity (Crawford, 2010). Behavioral factors of the increased intake (food) and less expenditure (physical activity) would lead to weight gain. Eating behaviors like skipping meals, eating less fruits and vegetables, fast foods, snacks, soft drinks and improper eating habits are linked to obesity (Caprio et al., 2008; Crawford, 2010). Consuming low nutrient and high-calorie foods is linked to SEP variables as well.

The second major question of this study was whether higher ADHD symptoms were associated with worse internalizing impairments. In this case, there was strong affirmative support. Students in the High ADHD group were more likely to be in the high depression, anxiety and stress groups and low self-esteem group. Although these associations are not always seen in clinical samples of adults (Cadman et al., 2016; Klein et al. (2012), they are typically observed in college samples (Anastopoulos et al., 2018). For example, Anastopoulos et al. (2018) found a comorbidity rate of 55% for at least one disorder and 31.8% for two or more conditions among college students with ADHD, compared to individuals without ADHD. Furthermore, leading comorbid disorders for those with ADHD were depression, anxiety and stress-related disorders. Anastopoulos et al.'s (2018) study supports the results found in this study by showing that there is a greater rate of comorbidity for those with high levels of adult ADHD-like behaviors.

Related results were found by Biederman et al. (2006) who conducted a 10-year prospective study in young adults with ADHD to analyze lifespan occurrences of psychopathology. At age 6-18 years, 140 children with ADHD and 120 without ADHD were assessed, and then they were re-evaluated at 10-year follow-up for many different psychiatric disorders, including mood, anxiety, antisocial, developmental and substance dependence disorders. Among the young adults with ADHD, all psychopathological disorders assessed were found to be greater compared to those without ADHD (Biederman et al., 2006). Findings indicate that those who have ADHD in childhood and adolescent years are at higher risk of psychopathology as young adults. Thus, assessing and treating ADHD in childhood years may be beneficial in preventing additional impairments and worse outcomes in adulthood.

Results from this study contribute to the literature by providing evidence of internalizing problems associated with ADHD-like behaviors in a community dwelling, non-clinical sample of college students, providing more information on the range of difficulties seen in the population. Our findings are consistent with Jacob et al. (2014), who focused on internalizing and externalizing behaviors in adults with ADHD, with a specific focus on personality traits. They conceptualized that internalizing behaviors of depression and anxiety characteristics may be observed by the personality traits of neuroticism and harm avoidance (high scores) (Jacob et al., 2014). Higher depression and anxiety, which were related to neuroticism and harm avoidance traits, were seen in those with ADHD compared to those without ADHD (Jacob et al., 2014).

Anastopoulos et al. (2018), Biederman et al. (2006) and Jacob et al. (2014) provided evidence for high levels of comorbidity among those with ADHD, especially internalizing problems and greater psychopathology for young adults in college with ADHD. Similarly, in the current study, greater likelihood of elevated internalizing impairments of depression, anxiety,

stress and low self-esteem were observed among college students in the High ADHD group. These impairments many lead to difficulties in academic, social and psychological functioning. Weyandt et al. (2013) found that a college sample (age 18-23 years old) of students with and without ADHD that individuals with ADHD had lower grades, less organization, greater executive dysfunction and higher levels of psychopathology (Weyandt et al., 2013). These functional impairments may be more severe, or their occurrence may be more likely among college students with ADHD and comorbid internalizing problems.

The third question in this study was whether higher BMI would be associated with greater depression, anxiety, stress and lower self-esteem. This was only partially affirmed. Individuals with high BMI were more likely to experience elevated Anxiety, but not depression, stress or low self-esteem. Main effects of ADHD and BMI on anxiety were qualified by a significant two-way interaction, such that individuals with both High ADHD and High BMI showed greatest likelihood of being in the High Anxiety group. This finding provided partial support for the fourth hypothesis. In contrast, BMI did not moderate the association between ADHD and depression, stress or self-esteem.

Obesity has been associated with higher anxiety in previous studies. Gariepy, Nitka and Schmitz (2009) investigated this association in community-residing adults in a meta-analysis of 16 studies. When obese and non-obese individuals were compared, those who were obese had a greater likelihood of having an anxiety disorder. This relation was strongest for individuals with severe obesity (i.e., BMI>=35) (Gariepy et al., 2009). Petry, Barry, Pietrzak, & Wagner (2008) studied the relation between overweight/obesity and psychiatric disorders utilizing data from 41,654 respondents to the National Epidemiologic Survey. BMI was associated with mood, anxiety and personality disorders, with moderate overweight associated with anxiety and

substance use, while obesity was associated with mood and personality disorders. Generalized anxiety, panic without agoraphobia, and specific phobia were the most common types of anxiety disorder among individuals who weight was beyond the normal range (Petry et al., 2008). Findings indicate common comorbid disorders with significant weight and also reveal differences among BMI classification.

Lykouras and Michopoulos (2011) attempted to understand why obesity and anxiety are associated with each other. Increased fear and excessive worry along with other symptoms such as fatigue, restlessness, tension, irritability and other symptoms, can negatively impact a person's life (Lykouras & Michopoulos, 2011). Anxiety disorders exhibit different neurobiology, phenomenology, behaviors and treatments, which contribute to the heterogeneity of the disorder. Obesity is also influenced by and influences the neurobiological, environmental, behavioral and social domains, resulting in increased heterogeneity and varied research findings (Lykouras & Michopoulos, 2011). For obesity, factors of social discrimination, low self-esteem, self- blame, comparison to others, constant thought of being thin, and increased medical conditions, can lead to psychological distress, worry, avoidance and therefore lead to anxiety (Lykouras & Michopoulos, 2011). For anxiety, dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis can occur, which leads to increased appetite, possibly increased intake of high caloric foods causing weight gain (Lykouras & Michopoulos, 2011). Other factors that can lead to anxiety and obesity are genetics, environmental factors, family environment, abuse during childhood, psychiatric disorders, medication and personality traits (Lykouras & Michopoulos, 2011). Many factors play a role in both anxiety and obesity, and both disorders have many layers to them that may decrease the quality of individuals' life.

Jarrett (2016) studied ADHD, anxiety and executive function in adults aged 17 to 25 years old. Results found that those with ADHD and anxiety had greater impairments with self-regulation of emotion, self-organization and problem solving compared to those with only one disorder. Executive function deficits are common among ADHD and anxiety by possible deficits in working memory or inhibitory control (Jarrett, 2016). Similarly, obesity has also been linked to similar deficits in executive functioning (i.e., inhibition and working memory), which may help to explain why ADHD, obesity and anxiety are related (Dassen, Houben, Allom & Jansen, 2018; Yang, Shields, Guo & Liu, 2018).

The comorbidity of ADHD and anxiety was also explored by Levy (2004) through the neurobiology of the disorders. Analyzing brain systems can contribute to the understanding of the comorbid relationship. The mesolimbic dopamine (DA) system comprises reward and goal-oriented interactions, which involve the tonic/phasic DA relationships (Levy, 2004). When impaired, low levels of dopamine in the mesolimbic area influences impulsive behavioral responses, which is seen in ADHD. In contrast, deficits in the synaptic gating process involve the prefrontal cortex, hippocampus and amygdala, resulting in comorbid anxiety (Levy, 2004). Impairment of the prefrontal cortex of lower inhibition leads to an increase of amygdala response, therefore greater anxiety (Levy, 2004). The deficits of these areas can lead to comorbidity in ADHD. Obesity can be influenced by many factors such as biological, executive functioning, environmental and social factors. Obesity is associated with the hormone leptin (involved in body weight), hypothalamus (regulates hunger) and a feedback loop (involved in sending signals). Anxiety has been linked to the hypothalamic–pituitary–adrenal (HPA) axis, which is associated with the stress hormone cortisol; with increased stress, there may be in food

intake (Lykouras & Michopoulos, 2011; Martin, Ressler, Binder & Nemeroff, 2009; Dallman, Pecoraro, & Fleur, 2005; Torres & Nowson, 2007), which may lead to weight gain and obesity.

Clinical Implications

The results from this study reveal an increased risk of internalizing impairments of depression, anxiety, stress and self-esteem in relation to those with higher ADHD symptoms in college students. For students with greater BMI, and students with both greater BMI and higher ADHD symptoms, there is a greater risk for anxiety. The findings of this study contribute to the literature of comorbidity among ADHD and BMI. Findings could shed light into the clinical assessment process for individuals reporting ADHD-like behaviors and/or who are overweight/obese. Clinicians should be sure to conduct a thorough history and assess or screen for potential comorbid problems, including internalizing factors like depression, anxiety, stress and self-esteem. Also, for young adults who are seeking treatment for ADHD, obesity or both issues, treatment for internalizing factors of depression, anxiety, stress or self-esteem, can be implemented as well. Multiple factors can be treated at the same time. Evidence based therapies can be implemented to improve symptoms of ADHD, overweight/ obese individuals and internalizing impairments.

Psychotherapy treatments such as cognitive behavioral therapy can be utilized. Bettis et al. (2017) recruited college students to investigate two interventions, the coping skills group and the cognitive training group, to determine the effectiveness in preventing mental health problems. In general, strategies across modalities had been shown to decrease anxiety, depression and general distress whether or not it was mindfulness, cognitive reappraisal and problem solving (Bettis et al., 2017). Although the two interventions did not produce significant results on depression, they were effective in reducing anxiety and stress, and showed benefit to

executive functions (Bettis et al., 2017). A greater level of decrease in problems of behavioral regulation and improvement in ADHD symptoms were noted with the cognitive training group compared to the coping skills group. This study demonstrated the benefits of interventions and in particular, recognized an association between coping, stress and executive function and symptoms of anxiety, depression and ADHD. A study by Geurts et al. (2020) examined mindfulness-based cognitive treatment for adults with ADHD. Mindfulness treatment entails attentiveness to experiences occurring at the moment with no preconceived, judgmental influences, thus allowing for the recognition of feelings, thoughts and sensations of the body, which will facilitate insight on how to change behaviors. With this treatment, there is a conscious effort, rather than an automatic reaction, involve in managing stressors to improve self-compassion and some specific areas of executive function (Geurts et al., 2020). A randomized controlled trial of mindfulness-based cognitive therapy (MBCT) plus treatment as usual (TAU) and treatment as usual alone (TAUA) with ADHD adults at intervals of three- and six-months had shown that improvement of mindfulness and self-compassion had no impact on reducing ADHD symptoms at six months (Geurts et al., 2020). However, an improvement was noted in self-compassion on positive mental health at 6-month follow-up. This finding indicated that individuals with ADHD benefited from a longer period of MBCT treatment that incorporated more self-compassion factors. Ramsay & Rostain (2016) conducted a study on clinic-referred ADHD adults and examined the effectiveness of evidenced-based cognitive behavioral treatment in improving self-regulation and motivational deficits. The functional and performance impairment observed in ADHD, such as difficulty in organization, management of tasks in a timely manner, procrastination, and inability to follow through with goals, had also led to difficulties in utilizing treatment recommendations efficiently (Ramsay & Rostain, 2016).

Specific strategies and tactics of cognitive, behavioral, implementation and mindfulness/ acceptance interventions had shown to decrease avoidance and promote the ability to follow through with the skills acquired (Ramsay & Rostain, 2016). The treatment approaches for adult ADHD had proven to be effective when applied daily in a consistent manner.

For treatment of weight, Wing et al. (2019) conducted a study of two interventions for the goal of weight gain prevention for six years in young adults age 18 to 35 years. Adults were randomly assigned to two self- regulated interventions Large Changes and Small Changes, frequently weighted themselves and implemented changes in diet or exercise based on treatment group. There was also a control group. At the end of six years, no group showed a significant difference in weight (Wing et al., 2019). At the end of the six years, the younger adults, less than 25 years, in the control group had greater weight compared to the other groups who lost more than 50% of their initial weight (Wing et al., 2019). In contrast, the older adults in the Large Changes group had reported below their initial weight at baseline, compared to the other groups who had above their initial weight. Those in the Large Changes group, who were encouraged to lose weight, showed greater effectiveness in losing weight over the 6 years. Weight gain in young adults is a serious problem that can lead to negative internalizing outcomes and medical problems later in life.

College students with higher ADHD symptoms, higher BMI or those with comorbid disorders of depression, anxiety, stress and low self-esteem, may face difficulties in everyday life. These students may find it difficult to get access to treatments, therapy or any type of resources that can be beneficial to them. Treatments may also be expensive. As an institution, colleges should have resources or provide services that can help students succeed in their college career and future endeavors. Specifically, at The City College Of New York, there is The

AccessAbility Center/ Student Disability Services (AAC/SDS) that offers students with different types of difficulties, accommodations and services to foster the learning process. For example, a student with diagnosed ADHD may access these resources to get extra time on an exam. The City College of New York also has a counseling center, where students can seek help for areas they are struggling with, such as concentration, mood difficulties, feelings of worry and anxiousness, and stress, just to name a few. College students who are facing impairments related to ADHD, obesity and internalizing factors should seek out the resources the college is providing. All colleges should offer assistance to their students.

Strengths

A strength of this study was its concentration on young adults in college and its racially diverse sample. Many studies - Cortese et al. (2013), Pawaskar et al. (2019), Zhao et al. (2008), Pagoto et al. (2009), Weyandt et al. (2013) - had an overwhelming proportion of their participants identify racially as white. The present study helps to extend the literature by including work on individuals who typically are not represented in research. Also, there has been limited work in focusing on a college student sample and especially in a non-clinical sample. Although the students in the present study complete questionnaires on ADHD, depression, anxiety and so on, the students were not necessarily diagnosed with ADHD. This study, therefore, helps to extend knowledge about the relations among these constructs within a wider range of behaviors, and at a less severe level than is seen in clinical populations.

Limitations

The present study has several limitations. First, this study was a cross sectional design, therefore measurements of BMI and ADHD symptoms, as well as internalizing outcomes were all measured at the same time point. As such, the temporal relations among the variables cannot

be determined. Although this study posited a path from ADHD to internalizing outcomes that was conditional on BMI, it is possible that BMI could be the outcome, with anxiety, mood, self-esteem or stress acting as a moderator. These questions require longitudinal data to better establish the relations among the variables.

Another limitation was the measure of body mass index (BMI), which was based on the participant's self- reported height and weight. Individuals can either underreport and/or over-report height or weight values. A study was conducted to compare self-report height and weight with objectively-measured height and weight to calculate BMI. Results found that 84% of respondents over-estimated their height and 74% underreported their weight (Hill & Roberts, 1998). Biases in self-reporting height and weight, would lead to inaccurate measurements of BMI.

Another limitation was the measure of ADHD symptoms. ADHD symptoms were determined by the ADHD-EF Index of the Barkley Deficits Executive Functioning Scale (Barkley, 2011), which consisted of only 11 items, all of which measure ADHD in adulthood, but not in childhood. According to the DSM-5 diagnostic criteria for ADHD, symptoms must be present before the age of 12 (APA, 2013). Age of onset was not determined in the current study. It would be helpful for participants to complete a psychiatric interview so they can be asked when symptoms were first noticed.

An additional limitation was that responses for depression, anxiety, stress and self-esteem scales were self-reported and reflected the subjects internalizing feelings. Participants may under or over-report symptoms based on how they were feeling when they filled out the questionnaires, may not want to report how they feel or reported based on what they think the study was observing.

Future Directions

Given that ADHD and BMI interacted to heighten risk for anxiety, further research should continue to investigate further internalizing impairment associated with this constellation of risk factors. For example, individuals may misuse substances to self-medicate to manage their symptoms and distress (Wilens et al., 2007). The additive effect of elevated ADHD and BMI on anxiety may have downstream effects in other domains including academic and social functioning – areas particularly important for college students. In focusing on academics for college students, their grades on papers and tests, and their general progress throughout college can be monitored. Exploration of social functioning can also be explored by evaluating how the students relates and communicates with family and friends.

Conclusion

This study contributes to the literature by observing ADHD symptoms, overweight/ obesity and the internalizing factors of depression, anxiety, stress and self- esteem, in a racially and ethnically diverse college sample. Elevated ADHD-like behaviors are associated with greater internalizing difficulties. When high ADHD is coupled with overweight/obesity, risk for severe anxiety is even greater. This study highlights the severe symptomatology observed among community-dwelling, high functioning college students. It also reinforces the importance of institutions having services available for students who are experiencing difficulties, and for clinicians to screen for internalizing problems among students who report high levels of ADHD-like behaviors.

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Appendix A: Rosenberg Self-esteem Scale (Rosenberg, 1965)

Instructions: Below is a list of statements dealing with your general feelings about yourself. If you strongly agree, circle **SA**. If you agree with the statement, circle **A**. If you disagree, circle **D**. If you strongly disagree, circle **SD**.

1.	On the whole, I am satisfied with myself.	SA	A	D	SD
2.*	At times, I think I am no good at all.	SA	A	D	SD
3.	I feel that I have a number of good qualities.	SA	A	D	SD
4.	I am able to do things as well as most other people.	SA	A	D	SD
5.*	I feel I do not have much to be proud of.	SA	A	D	SD
6.*	I certainly feel useless at times.	SA	A	D	SD
7.	I feel that I'm a person of worth, at least on an equal plane with others.	SA	A	D	SD
8.*	I wish I could have more respect for myself.	SA	A	D	SD
9.*	All in all, I am inclined to feel that I am a failure.	SA	A	D	SD
10.	I take a positive attitude toward myself.	SA	A	D	SD

Scoring: SA=3, A=2, D=1, SD=0. Items with an asterisk are reverse scored, that is, SA=0, A=1, D=2, SD=3.

Appendix B: Depression Anxiety and Stress Scale (DASS 21; Lovibond & Lovibond, 1995)

Instructions: Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you **over the past week**. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:
0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree or a good part of time
3 Applied to me very much or most of the time

1. (s) I found it hard to wind down	0	1	2	3
2. (a) I was aware of dryness of my mouth	0	1	2	3
3. (d) I couldn't seem to experience any positive feeling at all	0	1	2	3
4. (a) I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5. (d) I found it difficult to work up the initiative to do things	0	1	2	3
6. (s) I tended to over-react to situations	0	1	2	3
7. (a) I experienced trembling (e.g. in the hands)	0	1	2	3
8. (s) I felt that I was using a lot of nervous energy	0	1	2	3
9. (a) I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10. (d) I felt that I had nothing to look forward to	0	1	2	3
11. (s) I found myself getting agitated	0	1	2	3
12. (s) I found it difficult to relax	0	1	2	3
13. (d) I felt down-hearted and blue	0	1	2	3
14. (s) I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15. (a) I felt I was close to panic	0	1	2	3

16. (d) I was unable to become enthusiastic about anything	0	1	2	3
17. (d) I felt I wasn't worth much as a person	0	1	2	3
18. (s) I felt that I was rather touchy	0	1	2	3
19. (a) I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)	0	1	2	3
20. (a) I felt scared without any good reason	0	1	2	3
21. (d) I felt that life was meaningless	0	1	2	3

Note: d=depression item; a=anxiety item; s=stress item/