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Adolescent Body Mass Index in Relation to Depression, Self-Esteem, and Academic Achievement

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The differences in school achievement, depression, and self-esteem among overweight and normal weight adolescents were investigated. Body Mass Index (BMI), measured weight status, and group classification (overweight or normal weight) were determined by k-means cluster analysis. Multivariate analyses of variance (MANOVA) indicated significant effects across weight classifications. Overweight adolescents had a significantly lower grade point average than their normal weight counterparts. However, differences between weight groups for depression and self-esteem were insignificant. The implications and possible causes for these differences and similarities are discussed.

Recent research has documented extensively the adverse effects of obesity on orthopedic, neurological, pulmonary, and gastroenterological health (Must & Strauss, 1999; Zametkin, Zoon, Klein, & Munson, 2004). Overweight (Body Mass Index $\geq 85^{th}$ percentile for age and gender) and obese (Body Mass Index $\geq 95^{th}$ percentile for age and gender) individuals are at increased risk for a number of illnesses, including hypertension, hyperlipidemia, osteoarthritis, and Type II Diabetes, to name a few (Flegal, Carroll, Kuczmarski, & Johnson, 1998). Obese children between the ages of 10 and 13 have a 70% chance of being obese adults (The Office of the Surgeon General website, 2006). Given these findings, it is quite alarming to see the rates of childhood and adolescent obesity nearly triple in the USA, from 5.7% to 15.3%, between 1980 and 2000 (Ogden, 2002). These increases in childhood and adolescent obesity span age, gender, and ethnicity (Dietz & Gortmaker, 2001). While the health effects of the obesity epidemic in the United States have been examined in great detail (Dietz & Gortmaker, 2001; Flegal et al., 1998; Zametkin, Zoon, Klein, & Munson, 2004), not much attention has been directed toward other important effects, such as decreased school performance in children and adolescents, and the ramifications for professional life in adults.

Obesity and School Achievement

While the research on the relationship between obesity and school achievement has been sparse, it has also been varied in its parameters. Taras and Potts-Datema (2005) published a literature review examining 10 studies from the past 50 years coming from Brazil, China, Finland, Thailand, the United Kingdom and the United States of America (USA). Only four of these studies originated from within the USA (Datar, Sturm, & Magnabosco, 2004; Falkner et al., 2001; Schwimmer, Burwinkle, & Varni, 2003; Tershakovic, Weller, & Gallagher, 1994), even though the obesity problem in the USA is more pronounced than in other countries. In China, for example, Li (1995) examined an evenly matched cohort (obese and normal weight) of 204 elementary school children and found that severely obese children had significantly lower intelligence quotient (IQ) scores on the Wechsler Intelligence Scale for Children (WISC) than controls. Campos, Sigulem, Moraes, Escrivao and Fisberg (1996) found that children ages 8-13 years with normal height/weight ratios had significantly better performance on the WISC than their obese counterparts. In Thailand, Mo-suwan, Lebel, Puetpaiboon and Junjana (1999) found that being overweight during adolescence (grades seven to nine) was associated with poor school performance. Furthermore, adolescents who were more overweight were at greater risk for low GPA. Li (1995) found that obese children performed significantly lower in six of the eight categories examined: Chinese, arithmetic, foreign language, general knowledge, art, and gym. Defining obesity as greater than 120% of sex/height specific mean weight for age, Mikkila, Lahti-Koski, Pietinen, Virtanen and Rimpela (2003) found good school performance to be inversely associated with being obese for boys and girls in a cohort of over 60,000 Finnish adolescents, ages 14-16.

Within the USA, Datar, Sturm and Magnabosco (2004) analyzed data from a nationally representative cohort of 11,192 first-time kindergartners from the Early Childhood Longitudinal Study (ECLS), a project funded by the United States Department of Education. The ECLS began following these children in 1998 and will follow them through twelfth grade in order to test hypotheses about the effects of a wide range of family, school, community and individual variables on children's development, early learning, and early performance in school. The overweight kindergarteners enrolled in the ECLS had significantly lower math and

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reading test scores compared with the non-overweight children. However, once they included socioeconomic and behavioral variables in their model, Datar's group concluded that overweight status is a marker, and not a causal factor, of poor test scores (Datar et al. 2004).

The Affective Component

Clinical reports and other qualitative data seem to indicate that weight is linked to both depression and self-esteem. However, recent studies on adolescents concerning emotional health indicate that the data are not so clear-cut. Swallen, Reither, Haas and Meier (2005) found that while overweight and obese adolescents (ages 15-17) had significantly worse self-reported health than normal weight adolescents, no difference existed between the groups on measures of depression, self-esteem, and school/social functioning. Several other studies found no differences in self-esteem between obese children and adolescents and non-obese controls (Gortmaker et al., 1993; Renman, Engstrom, Silfverdal, & Aman, 1999; Rumpel & Harris, 1994). Other studies indicate that obese children and adolescents have somewhat lower self-esteem than their normal weight counterparts (Manus & Killeen, 1995; Stradmeijer, Bosch, Koops, & Seidell, 2000; Strauss, 2000). Still others found a difference in self-esteem between obese and normal weight children and adolescent girls that was rendered insignificant once body image was controlled for (French, Perry, Leon, & Fulkerson, 1995; Pesa, Syre, & Jones, 2000).

Similar problems of confounding variables arise when examining the relationship between obesity and depression. Sjoberg, Nilsson and Leppert (2005) concluded that there is a significant statistical association between adolescent obesity and depression, although it disappeared when shaming experiences, parental employment, and parental separation were controlled for. These findings were similar to those of Erickson, Robinson, Haydel and Killen (2000), although they were studying a cohort of children in the third grade. In girls, they found a modest association ($r = 0.14$, $p < .01$) between depressive symptoms and Body Mass Index (BMI), which dropped out after controlling for level of overweight concerns. Erickson et al. (2000) found no association between depressive symptoms and BMI in boys.

The objective of this study of eleventh graders, in the USA, was to build on prior evidence (Datar et al., 2004; Mikkila et al., 2003; Mo-suwan et al., 1999) that has suggested that there exists a negative relationship between BMI and school achievement. As BMI increases, school achievement, measured here by grade point average (GPA) is expected to decrease. Due to the conflicting evidence presented by the literature concerning the relationship between BMI and depression, we do not expect to see a relationship between BMI and depression (Sjoberg et al., 2005; Swallen et al., 2005; Erickson et al., 2000). Additionally, no relationship is expected between BMI and self-esteem (Swallen et al., 2005; Renman et al., 1999; Rumpel & Harris, 1994; Gortmaker et al., 1993). Current research efforts into the possible biological correlates of obesity that have an impact on cognition will be examined.

Method

Sample

Participants in this study consisted of students in eleventh grade attending a public high school in an affluent community in the Northeast. During the year 2000, the median annual family income in this region was reported to be almost $102,000 (U.S. Census Bureau, 1999); the highest national median income ever recorded by the U.S. Census is $43,318 (DeNavas-Walt, Proctor, & Mills, 2004). The majority of students, 87.1%, were of European American background, 0.8% were African American, 5% were Hispanic, 4.2% were Asian American, and 2.9% were of other ethnic backgrounds. With regard to gender of the students, 46.7% were female and 53.3% were male.

This study was implemented as part of a school-based initiative that targeted positive youth development, and inclusion of students in the sample was based on passive consent procedures (i.e. students are automatically included and given the opportunity to opt-out at any point, before, during, or after the study). Given increasing anecdotal and media-based evidence of various problems in communities such as theirs, school administrators and parent representatives in this particular community had sought a rigorous assessment of the nature and extent of difficulties among their high school students. Following the development of a collaborative relationship between the local school district and a Columbia University researcher, Dr. Suniya Luthar (which ensued from a series of talks she gave for the community), the survey was initiated. School administrators sent letters to the parents of all eleventh graders by U.S. mail that described the project, indicated that survey results would be presented only in aggregate form (with no information on individual children), and requested notification if they preferred that their children not participate. A second notice was mailed a few days before data collection, once again offering parents the option to refuse consent. On each of the two days of data collection, all students were also told that their participation was entirely voluntary. On completion of data collection, questionnaires were scored with only participant numbers as identifiers. Most of these students had participated in similar data collections conducted by Dr. Luthar during the sixth through tenth grades. Of the 252 eleventh graders who participated, BMI data was available for only 240 of the students; 12 students did not report their heights and weights.

Measures

Subjective Reports of Maladjustment

Depressive symptoms.

The Children's Depression Inventory is a widely used 27-item, three-choice scale designed to measure depression for school-age children and adolescents (Kovacs, 1992). This measure has acceptable internal consistency as well as criterion and concurrent validity (Kovacs, 1992). Alpha coefficients of internal consistency in this sample were .82 and .84 for girls and boys, respectively.

Self-Perception Profile for Adolescents.

The global self-worth subscale from the Self-Perception Profile for Adolescents (Harter, 1988) was administered to tap each participant's overall perception of his or her worth as a person. Item content examines the extent to which adolescents approve of themselves along four dimensions: (a) social competence, (b) physical competence, (c) romantic appeal, and (d) friendship. For each item, two sentence stems were presented side by side, for example, "Some teenagers are often disappointed with themselves," but "Other teenagers are pretty pleased with themselves." Students were asked to decide which stem best described them and whether the statement was "sort of true" or "really true" for them. Questions are written in a "structured alternative format" designed to reduce the tendency to give socially desirable responses (Harter, 1982). Harter (1988) reports good psychometric characteristics for these scales. Alpha coefficients of internal consistency in this sample were .96 and .89 for girls and boys, respectively.

Objective Reports of Maladjustment

Body mass index.

BMI is a measure of the weight of a person scaled according to height. A frequent use of BMI is to assess how much an individual's body weight departs from what is normal for a person of his or her height. The weight excess or deficiency may, in part, be accounted for by body fat (adipose tissue) although other factors, such as muscularity, also affect BMI. As a rough guideline for adults, a BMI of less than 20 implies underweight, over 25 is overweight, and over 30 is obese. BMI is calculated by taking the weight of the individual in kilograms and dividing by the square of the height in meters. BMI for children age 2 to 20 is calculated just as it is for adults, but it is classified differently. A BMI that is less than the 5th percentile is considered underweight and above the 95th percentile is overweight. Children with a BMI between the 85th and 95th percentile are considered to be at risk of becoming overweight. BMI categories are generally regarded as a satisfactory tool for measuring whether sedentary individuals are "underweight," "overweight," or "obese." It has been used by the World Health Organization as the standard for recording obesity statistics since the early 1980s. Additionally, Piertobelli et al. (1998) tested the hypothesis that in a healthy pediatric population, BMI is a valid measure of fatness (total body fat and percent of body weight as fat were estimated by dual energy x-ray absorptiometry). The measure is also independent of age for both sexes (Piertobelli et al., 1998). Research thus supports the use of BMI as a fatness measure in groups of children and adolescents. Goodman and Strauss (2000) found self-report of BMI by adolescents to be a reliable indicator of actual BMI; 96.2% of teens were correctly classified as obese based on self-reported height and weight measures.

Procedure

Data for each student were collected during two 45-minute class periods on two separate days, and testing of the adolescents was done in groups of 15 to 20. To guard against biases due to variability in reading proficiencies, a member of the research team read each questionnaire aloud, and students marked their responses accordingly. Questionnaires were administered in the same order to all groups, with relatively structured, non-threatening measures administered at the beginning and end of each session. Students reported height and weight data in the demographics section. On completion of data collection, money to support a pizza party was given to all participating classes. Following the data collection, GPA was obtained directly from school administrators.

Results

Complete data were obtained for 238 of the eleventh graders who were attending the school sampled; the school withheld GPA for two of the students for reasons unknown to the investigators. Means and standard deviations on all variables are presented in Table 1. A k-means cluster analysis was performed on BMI to create two groups with maximum distance between group averages. Multivariate analyses of variance (MANOVA) indicated significant effects across weight classifications (Wilks's $\lambda = .959$, $p < .05$). Individual t-tests showed a significant difference between

Table 1
Descriptive Data on All Variables

	Weight Classification				
	Normal (BMI = 21.09) (n = 208)		Overweight (BMI = 29.48) (n = 28)		
	M	SD	M	SD	*F*
Grade Point Average[a]	9.10[b]	1.94	7.88	2.07	9.604**
Depression	7.51	5.45	8.03	5.63	0.225
Global Self Esteem	3.18	0.52	3.05	0.40	1.625

[a] GPA measured on a 12 point scale, 12=A, 9=B, 6=C, 3=D
[b] Means are convertible to standard collegiate 4-point scale by dividing by 3; subsequent group means are 3.03 and 2.63, respectively.
** $p < .01$

classifications for GPA ($F = 9.604$, $p < .01$), but not for depression ($F = .225$, $p = .636$), or global self-esteem ($F = 1.625$, $p = .204$). Error variance of all dependent variables was equal across groups and homogeneity was not violated.

Discussion

This study replicates findings of a strong association between BMI and GPA (Mikkila et al., 2003; Mo-suwan et al., 1999), while also furthering hypotheses that BMI is not associated with depression (Erickson, 2000; Swallen, 2005) or self-esteem (Gortmaker, 1993; Renman et al., 1999; Rumpel & Harris, 1994). Normal weight adolescents had an average GPA of 3.03 (when grades were converted to a standard collegiate 4-point scale), in comparison to an average GPA of 2.63 for the overweight group. Miller (1998) found that high school grades "have a strong and significant effect on earnings 9 years after high school for both men and women, with or without bachelor's degrees," even after controlling for SES, race/ethnicity, region of the country and public or private status of the high school. While it was beyond the scope of this study to examine why overweight students are performing worse in school than their normal weight counterparts, current research efforts in the field suggest that certain structural and chemical differences in the brain among overweight individuals adversely affect memory and cognitive functioning (Jeong, Nam, Son, Son and Cho, 2004; Pannacciulli et al, in press).

Pannacciulli et al. (in press) examined associations between excess body fat and regional alterations in brain structure using voxel-based morphometry. In comparison with the group of lean subjects, the group of obese individuals had significantly lower gray matter density in several regions in the brain. In general, gray matter can be understood as the parts of the brain responsible for information processing. Pannacciulli et al. identified structural brain differences associated with obesity in several brain areas involved in the regulation of reward and behavioral control, two processes that, along with information processing, have a significant impact on learning. Jeong, Nam, Son, Son and Cho (2004) used measurements of BMI and waistline circumference to study a Korean sample of 467 adults over age 64. Waistline circumference was included to better identify those adults who were overweight due to excess body fat and not due to other causes such as greater muscle mass or enlarged skeletal structure. Poor cognition was strongly associated with obesity (BMI $\geq$ 25) in the presence of abdominal obesity. In Korea, a BMI $\geq$ 25 is defined as obese while a BMI of 23-25 is defined as overweight. In individuals with normal waist circumference, poor cognition was negatively associated with being overweight. Additionally, abdominal obesity interacted with BMI in its association with poorer cognition. In this elegant study, Jeong, Nam, Son, Son, and Cho (2004) were able to isolate the effects of abdominal obesity (i.e. excessive body fat) on cognition above and beyond having elevated BMI. Finally, several other studies have shown that insulin deficiency, acute hyperglycemia and poor glucose tolerance are associated with impaired memory and cognitive dysfunction in the elderly (Craft, 2005; Stockhorst, de Fries, Steingrueber, & Scherbaum, 2004; Sommerfield, Deary, & Frier, 2004; Convit, Wolf, Tarshish, & de Leon, 2003). These conditions are more prevalent in obese populations, and are a consequence of Type II diabetes, a weight-related disorder.

In addition to the biological effects on learning, cognition and memory, there is a socio-cultural impact on student's academic outcomes. Unfortunately, at present, there is a dearth of quantitative research on this matter (Puhl & Brownell, 2001). The only examination of this topic known to this author found that obese adolescents were significantly less likely than their normal weight counterparts to gain college admission, despite equivalent academic records and application rates (Canning & Mayer, 1966). While there has been considerable attention directed towards the harassment of, and shame wrought upon, obese children and adolescents in the school setting (Neumark-Sztainer, Story, & Harris, 1999; National Education Association, 1994; Crandall, 1994), no attention has been paid to the direct or indirect effect this has upon their grades.

While other studies have found mixed results when examining the relationship between obesity and depression in adolescents (Sjoberg et al. 2005; Erickson et al., 2000), this study did not ($p=.636$). Richardson et al. (2003) conducted a study of New Zealand adolescents that may explain why this is so, at least for girls. They found that girls with major depression in late adolescence were twice as likely to be obese at age 26. The heterogeneous etiology of depression and subsequent complex effects this disease has on an individual likely explains why this study found no relationship with obesity. While some depressed adolescents may be obese, others have not yet experienced the effects of depression on their bodies. In essence, they may be too young for depression to have had an effect on their weight.

Many researchers use the global self-worth subscale from the Self-Perception Profile for Adolescents (Harter, 1988) as a valid measure of self-esteem (French et al, 1995; Strauss, 2000; Strodmeijer et al., 2000). While the four dimensions tapped by this instrument (social competence; physical competence; romantic appeal; and friendship), are areas in which obese adolescents experience difficulty (Puhl & Brownell, 2001; Neumark-Sztainer et al., 1999), normal weight adolescents also experience difficulty in these areas. Put more succinctly, it is not surprising that in this study the relationship between self-esteem and obesity was not statistically significant ($p=.204$); self-esteem is an issue with which most, if not all, adolescents struggle.

Limitations and Conclusion

One limitation of this study is sample size. Weight classification groups are of unequal size, and the size of the

overweight group (N=28) significantly impacts the power of this study to examine all possible risk factors of elevated BMI. In a study such as this one, power of .8 or greater is ideal (Cohen, 1988). While the power of individual t-tests examining differences in depression (.076), and self-esteem (.246) between weight class groups in this study is less than ideal, this discrepancy is not significantly meaningful in this case. Extrapolating to larger group samples, it is unlikely that greater power would alter statistical significance between weight group averages on the CDI because the distributions are homoscedastic. A similar pattern of insignificant group differences, homoscedasticity, and negligible clinical differences is observed when examining the group differences in self-esteem. Sample size further limits the ability to examine path models that may indicate direction of causality.

The devastating effects of obesity have gained national attention in the United States and articles are written weekly documenting these effects. Studies examining the biological effects of obesity on cognition are a recent development. More work needs to be done in this area, especially replicating findings in younger populations and with samples that are a better representation of the population at large. The results reported here indicate that physical factors such as obesity are a good indicator to parents and school administrators that a child may be doing poorly in school.

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