Impact of Body Mass Index on Postconcussion Symptoms in Teenagers Aged 13 to 18 Years

Harry Bramley, DO; Kathryn C Foley, MD; Ronald Williams, MD; Mechelle M Lewis, PhD; Lan Kong, PhD; Matthew Silvis, MD

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ABSTRACT

Context: Adolescent obesity and sports-related concussion are rising in prevalence, yet there is minimal research exploring the relationship between these two conditions.

Objective: To assess the impact of body mass index (BMI) percentile on duration of recovery and reported symptoms after sports-related concussion in adolescents.

Design: Retrospective chart review at a regional concussion program located at an academic medical center. Medical records of all patients aged 13 to 18 years treated from March 2006 through January 2012 were reviewed. Two hundred fifty-two patients met the inclusion criteria of sports-related concussion and having BMI data.

Main Outcome Measures: Outcome variables included reported emotional symptoms, sleep-related symptoms, physical symptoms (headache), and time to recovery after a concussion. Explanatory variables in this analysis were BMI percentile and sex.

Results: More male patients were obese and overweight than were females (42% vs 27%, $p = 0.02$). There was no statistically significant difference in recovery time between obese and overweight patients and others. Obese and overweight patients were more likely than healthy-weight patients to report symptoms of irritability ($p = 0.05$) and impulsivity ($p = 0.01$), and less likely to report headache ($p = 0.03$).

Conclusion: After concussion, irritability and impulsivity may be more likely than headaches in overweight and obese patients. There was no difference in recovery time between obese and healthy-weight teens. These findings may have importance in the evaluation, treatment, and anticipatory guidance of patients with concussions.

INTRODUCTION

Childhood and adolescent obesity has become a major public health crisis in the US.[1] According to the National Health and Nutrition Examination Surveys from 1988 to 1994 and from 2005 to 2008, the proportion of adolescents aged 12 to 19 years who are considered obese rose from 10.5% to 17.9% between those periods.[2] An update from the Centers for Disease Control and Prevention for 2015 to 2016 shows the prevalence has risen to 20.6% for this age group.[3] Although reports show that this increasing rate of childhood obesity might be slowing, the prevalence of obese and overweight children and adolescents in the US continues to grow, and the sequelae are becoming more evident with increasing research.[4,5] A previous study showed that childhood obesity is related to adult adiposity.[6] The epidemic of childhood obesity in the US also has ushered in a host of other diseases in children that previously were not typically seen until much later in life, such as type 2 diabetes mellitus, hypercholesterolemia, and primary hypertension.[7-11]

The terms *obese* and *obesity* often are used to describe excess body fat.[12] Body mass index (BMI) is a measure of body fat based on weight in relation to height, and is calculated using the formula weight (kg)/height (m^2), which is how obesity generally is classified.[2] For children aged 2 to 19 years, BMI percentile is used to denote children as obese, overweight, healthy weight, or underweight.[13] Children are classified as obese if their BMI is greater than or equal to the 95th percentile of others their age and sex.[13] A BMI between the 85th and 95th percentiles is considered overweight.[13] Children are classified as normal (or healthy) weight if their BMI is between the 5th and 85th percentile, and underweight children are those with a BMI less than the 5th percentile for age and sex.[14]

In 2012, fully 34.5% of adolescents aged 12 to 19 years in the US were either obese or overweight.[5] In light of this national epidemic of obese or overweight adolescents, it is becoming increasingly important to consider the ways in which excess body fat may affect common conditions and injuries in adolescents. One such injury of particular relevance in this age group is concussion, which is defined by the 5th International Consensus Conference on Concussion in Sport as the immediate and transient symptoms of traumatic brain injury induced by biomechanical forces.[15]

The number of children aged 14 to 19 years with sports-related concussions increased 2- to 3-fold between 1997 and 2007.[16] An estimated 173,000 children report to the Emergency Department with sports-related concussions each year in the US, with concussion being diagnosed in approximately 1 in every 160 patients reporting to the Pediatric Emergency Department.[17] The rising number of high school athletes with diagnoses of sports-related concussion likely is caused by a combination

Harry Bramley, DO, is an Associate Professor of Pediatrics at Penn State Hershey Children's Hospital in PA. E-mail: hbramley@pennstatehealth.psu.edu. **Kathryn C Foley, MD,** is a Resident at Alfred I DuPont Hospital for Children in Wilmington, DE. E-mail: kathryn.cantore@gmail.com. **Ronald Williams, MD,** is a Professor of Pediatrics and Medicine at Penn State Hershey Children's Hospital in PA. E-mail: rwilliams@pennstatehealth.psu.edu. **Mechelle M Lewis, PhD,** is an Associate Professor of Neurology at Penn State Health Milton S Hershey Medical Center in PA. E-mail: mlewis5@pennstatehealth.psu.edu. **Lan Kong, PhD,** is a Professor of Biostatistics in Public Health Services at Penn State Health Milton S Hershey Medical Center in PA. E-mail: luk14@psu.edu. **Matthew Silvis, MD,** is a Professor of Family and Community Medicine and Orthopedics and Rehabilitation Medicine at Penn State Health Milton S Hershey Medical Center in PA. E-mail: msilvis@pennstatehealth.psu.edu.

of higher rates of injury and increased awareness and reporting.[18,19] Younger patients, compared with adults, are at higher risk of concussions with increased severity and prolonged recovery.[20,21]

As the incidence of concussion in high school athletes increases, there is a need for further research into the individual factors predictive of postconcussive symptoms and duration of recovery. Given the increasing incidence of concussion in the context of a national epidemic of obesity in the same age population, the potential relationship between these two factors must be considered. Recent study results have been contradictory. A recent report found obese athletes took longer to recover after a sports-related concussion compared with normal-weight athletes.[22] Morgan et al,[23] however, found BMI was not a predictor of postconcussion syndrome after sports-related concussion in the study population.

The primary goal of this study was to assess the impact of BMI percentile on duration of recovery and reported concussion symptoms in the adolescent population with sports-related concussion. Additionally, this study aimed to report the prevalence of pediatric obesity in male and female teenagers in this population.

METHODS

Study Participants and Procedures

Eligibility criteria for inclusion in this study included age 13 through 18 years and a clinical diagnosis of sports-related concussion. *Sports-related* was defined as court or field activity related. High-velocity sports-related activities such as skiing, motocross, and bicycling were not included. Patients included in the study were all those meeting the eligibility criteria who were referred to a regional concussion program between March 2006 and January 2012. For patients who had multiple concussions during the review period, only information from the first concussion was used in the analysis.

A retrospective chart review was performed, with data collected from patient medical records and entered into a concussion database. A panel of reviewers obtained data regarding age at initial visit, sex, date of concussion, date of initial clinic visit, date of last clinic visit, mechanism of injury, previous concussions, reported concussion symptoms, and height and weight within one year of injury. The concussion clinic was staffed by two physicians who had performed the evaluations for each patient documented in the electronic medical record, facilitating the data collection process. Whereas individual symptoms varied between patients, all patients were evaluated and treated similarly in this concussion program. Physicians obtained the history from the patient, assessed for concussion symptoms, provided an examination, and formulated an assessment and plan. No specific assessment tool was used. Length of time to recovery was defined as the number of days from the date of injury to the last clinic visit indicating concussion resolution. Patients were excluded from the study if there was no documented date of injury, if the last clinic visit suggested ongoing concussion symptoms or follow-up was recommended, and if height and weight within one year of concussion could not be obtained.

The study was approved by Penn State Hershey Medical Center's institutional review board before data collection.

Statistical Analysis

The outcome variables of interest included reported emotional symptoms, sleep-related symptoms, physical symptoms, and time to recovery after a concussion. Reported emotional symptoms included feeling anxious, irritable, sad or depressed, impulsive, angry, argumentative, having mood swings, and feeling more emotional. Reported sleep-related symptoms included fatigue, drowsiness, trouble falling asleep, trouble staying asleep, sleeping more, and sleeping less. The reported physical symptom was headache. The explanatory variables in this analysis were BMI percentile and sex. The BMI percentiles were calculated using the Centers for Disease Control and Prevention's online information: "Children's BMI Tool for Schools."[24] The BMI percentile was analyzed as an explanatory value in 4 distinct ways: 1) as a continuous variable; 2) as 4 categories defined as obese (≥ 95th percentile), overweight (85th to < 95th percentile), healthy weight (5th to < 85th percentile), and underweight (< 5th percentile); 3) as obese vs all others; and 4) as obese and overweight vs healthy weight and underweight.[14]

The Wilcoxon signed rank test was used to compare medians among the different variables. Chi-squared test was used to determine whether there was a significant difference between frequency of reported symptoms and sex, as well as between BMI and reported symptoms. The Fisher exact test was used for the same purpose when variables had expected counts less than 5. The Kruskal-Wallis equality-of-populations rank test was used to compare the homogeneity of the samples regarding sex, BMI percentile, and BMI category as it related to recovery time. The Cochran-Mantel-Haenszel statistic was used to analyze whether there was a significant difference in the median BMI percentile between those who reported a symptom and those who did not.

All p values < 0.05 were considered statistically significant. SAS Version 9.3 (SAS Institute Inc, Cary, NC) was used for all statistical analyses.

RESULTS

Study Patients

Of the 577 patients included in the concussion program database from the period analyzed, 303 patients met the eligibility criteria for this study, of which 252 had BMI data and were included in the analysis. From this population, 166 (66%) were male and 86 (34%) were female. Twenty-five (10%) of the patients included were obese, 68 (27%) were overweight, 157 (63%) were healthy weight, and 2 (1%) were underweight. The mean BMI percentile (SD) was 71.5 (22.4), and the median was 77.8.

Body Mass Index and Sex

Of the male patients included in this study, 21 (13%) were obese, 48 (29%) were overweight, 96 (58%) were healthy weight, and 1 (0.6%) was underweight. Of the female patients, 4 (5%) were obese, 19 (22%) were overweight, 62 (72%) were healthy weight, and 1 (1%) was underweight. There was a statistically significant difference in the frequency of obesity between male and female patients (p = 0.045). Additionally, there was a statistically significant difference in the frequency of obese plus overweight patients when males were compared with females (p = 0.02).

Body Mass Index and Time to Recovery

The mean number of days to recovery was 105 in obese patients, 129 days in overweight patients, 116 days in healthy-weight patients, and 289 days in underweight patients. The median number of days to recovery in obese, overweight, healthy-weight and underweight patients was 26, 61, 40, and 289, respectively. The Kruskal-Wallis test was not reliable for this analysis because the underweight group was too small (n = 2). There was no statistically significant difference in recovery between obese patients and all others (p = 0.13) or between obese and overweight vs healthy weight and underweight (p = 0.46).

Body Mass Index and Symptoms

There was a statistically significant difference in the frequency of reported symptoms between patients in different BMI categories and symptoms of irritability, impulsivity, and headache (Figure 1). Obese and overweight patients were significantly more likely to report symptoms of irritability vs healthy-weight and underweight patients (p = 0.048). A similar result was found for impulsivity, with obese and overweight patients significantly more likely to report symptoms of impulsivity vs healthy-weight and underweight patients (p = 0.01).

Headache was the most common symptom for all patients, with 85% of patients reporting headache. Headache was statistically more likely to be reported by healthy-weight and underweight patients vs obese and overweight patients (p = 0.03). In addition, the median BMI percentile of those reporting headache was significantly lower vs patients without headache (75% vs 88%, p = 0.02).

Body Mass Index and Football versus Nonfootball Players

There was no statistically significant difference between the BMI of patients (all male) with football-related concussions (n = 78) and other male patients (n = 79). There were 35 obese and overweight football players and 32 obese and overweight male nonfootball players (p = 0.58).

DISCUSSION

Because of the increasing prevalence of both obesity and concussion among adolescents, it is important to understand how these two factors may interact and/or affect each other. To date, there is minimal evidence exploring this relationship. One study found obese athletes to be at greater risk of increased recovery time after a sports-related concussion, whereas another report suggested BMI was not an associated risk factor for the development of postconcussion syndrome.[22,23]

In the current study, overweight and obese patients with concussion were more likely than healthy-weight and underweight patients to report symptoms of irritability and impulsivity. Psychological complications of pediatric obesity include

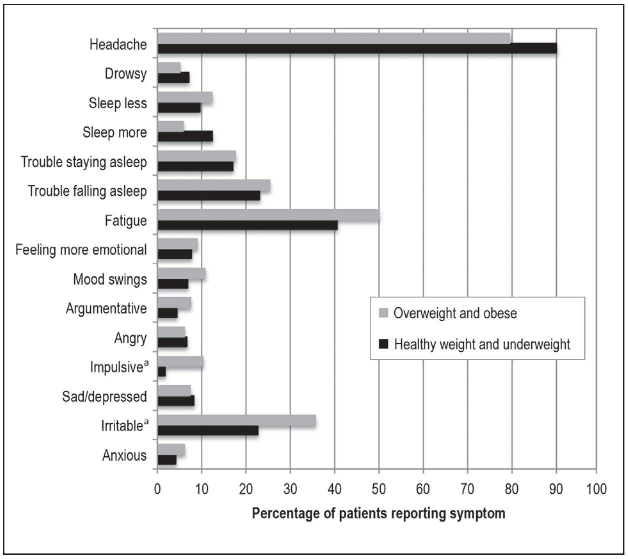

Figure 1. Postconcussion symptoms by body mass index category.

Overweight and obese patients were significantly more likely to report symptoms of impulsivity (p = 0.01) and irritability (p = 0.05) compared with healthy-weight and underweight patients, whereas they were less likely to report headache (p = 0.03).
[a] $p < 0.05$.

social stigma, depression, and low self-esteem.[25] Although our data did not find a difference in the reporting of depression between overweight and obese patients compared with healthy-weight and underweight patients, irritability may suggest depression.[26,27] In addition, asking patients if they are sad or depressed is not an accurate screening tool for depression.[28,29] This may be especially important to consider because a common practice in concussion evaluation and management in athletes is completion of the Sports Concussion Assessment Tool 3 (SCAT3) that addresses the following 4 emotional symptoms: More emotional, irritability, sadness, and nervous or anxious.[15] In addition, it has been reported that postconcussion symptom scales do a poor job of identifying patients with a psychiatric disorder.[30] A more extensive screening using a depression and anxiety screening tool, such as the Patient Health Questionnaire (PHQ-9), should be considered in overweight and obese patients with concussion.

It is unclear why overweight and obese patients were less likely to report headache compared with healthy-weight and underweight patients, although the rates of reported headache in both groups were high. *Posttraumatic headache* is defined as a headache that develops within 7 days after head trauma or regaining consciousness; the incidence of reported headache after a concussion ranges from 31% to 96%.[31-35] Posttraumatic headache usually resolves within a few weeks, but some patients may experience chronic headaches.[36] Being overweight or obese did not appear to be a risk factor for the development of chronic headache or a more prolonged recovery time. It is important to assess for headache in all patients after concussion and to provide appropriate anticipatory guidance and treatment.

This study showed that adolescent male athletes who suffer a concussion are more likely to be obese or overweight compared with adolescent female athletes who suffer a concussion. If there is a higher rate of obesity in the male population compared with females, this may reflect the population. Football is a common mechanism for concussion in adolescent boys but not in adolescent girls, and the average BMI for football players may be higher compared with athletes who participate in other sports. There was no statistically significant difference in BMI, however, between football players and other male athletes. Additional studies to better understand this observation are warranted. Female sex has been shown to be a factor in extended recovery time.[37] However, we did not assess this in our study. Race has been previously studied and shown not to be a factor.[23]

This study has several limitations. Although the sample size was relatively large, the study was a retrospective chart review and the number of subjects that fell into the underweight BMI category was very small. Height and weight were not measured for all patients at presentation to the concussion clinic and had to be obtained from other patient encounters. Information on BMI was included in the study if it was measured within 1 year of the date of concussion, which may reduce accuracy if there was rapid weight gain or loss. Of the 303 patients who met inclusion criteria for the study, BMI data were not available for 51 (17%) of the patients, and these patients were excluded from the study. BMI itself is a screening tool and has some limitations; however, it is a simple way to estimate adiposity. In fit athletes, BMI may overestimate total body fat because muscle weighs more than fat and athletes tend to have a higher proportion of muscle compared with the general population. Measuring total body fat is a better predictor but is difficult to accomplish. Resolution of concussion was defined as the final visit, which may have overestimated recovery time. The rate of no-shows and incomplete follow-up ("lost-to-follow-up") was not assessed. This rate was estimated, however, to be low at approximately 5% but may underestimate the time of recovery because these patients were not included in the study. Although every effort was made to capture all patients within the designated timeframe, some may have been missed. Finally, all patients were seen at a regional concussion clinic in central Pennsylvania, and the results may not reflect patient populations from other regions.

CONCLUSION

Overweight and obese patients with concussion were more likely than healthy-weight and underweight patients to report symptoms of irritability and impulsivity, and were less likely to report headache. This study did not find an association between obesity and concussion recovery time. These findings might assist the clinician in the evaluation, treatment, and anticipatory guidance of patients with concussions. This is the second known study that has found an association between BMI and sports-related concussion. Additional well-designed studies should be developed to better determine causality. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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Rattling Around

Scarily, football helmets, which do a fine job of protecting against scalp laceration and skull fracture, do little to prevent concussions and may even exacerbate them, since even as the brain is rattling around inside the skull, the head is rattling around inside the helmet.

— Jeffrey Kluger, b 1954, *Time Magazine* senior science writer