JOURNAL OF POSNA

Volume 4, Number 3, August 2022

Original Research

No Postoperative Change in Body Mass Index Was Observed Among Adolescent Female Patients After Sports or Trauma Surgery

Alexandra T. Mackie, PB-BS, BA[1]; Nicolas Pascual-Leone, BA[1,2]; Francesca R. Coxe, MD[1]; Peter D. Fabricant, MD, MPH[1,3]; Shevaun M. Doyle, MD[1,3]

[1]Hospital for Special Surgery, New York City, NY; [2] Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA; [3]Weill Cornell Medical College, New York City, NY

Correspondence: Shevaun M. Doyle, MD, Pediatric Orthopaedic Surgery, Hospital for Special Surgery, Weill Cornell Medical College, 535 East 70th St., New York, NY 10021. E-mail: doyles@hss.edu

Received: January 19, 2022; Accepted: April 23, 2022; Published: August 1, 2022

DOI: 10.55275/JPOSNA-2022-0049

Abstract:
Purpose: The purpose of this study was to identify whether adolescent females are more prone to postoperative BMI decreases when compared to other female age groups and all male age groups. We hypothesized postoperative BMI would decrease in adolescent females when compared to males and younger females.

Methods: A list of patients aged 5 to 19 who underwent surgery from 2016-2020 was generated with the 50 most frequently used diagnosis codes of two orthopaedic surgeons at an orthopaedic hospital. Patients were excluded if they had undergone multiple surgeries. BMI data was collected at baseline and 2-8 months post-surgery. Patients were divided in cohorts by age: school-age, pre-adolescent, and adolescent.

Results: A total of 156 patients were analyzed with a mean BMI of 20.9. There were 24 school-aged, 72 pre-adolescent, and 60 adolescent patients. No statistically significant difference in BMI change was noted between groups as determined by one-way ANOVA (p=0.86).

Conclusion: There were no significant postoperative changes in BMI between males and females over the time intervals measured. Further research focused on subtle changes in eating habits is necessary to determine if eating disorders develop without BMI changes following surgical intervention.

Level of Evidence: Level III

Key Concepts:

- There was no measured difference in postoperative BMI change over the time period studied.
- Future studies should expand the time period to determine if there is a risk of eating disorders further into the postoperative course.

Introduction

Following injury, female athletes are at increased risk of developing disordered eating habits, which has been attributed to the lifestyle changes associated with sports injuries.[1,2] Disordered eating commonly is defined as an abnormal eating behavior involving restrictive eating, fasting, skipping meals, using diet pills, laxatives, diuretics, enemas, or binge eating followed by purging (i.e., vomiting).[3,4] Many of these behaviors are formed in adolescence, enhancing the susceptibility of the young female athlete population to develop disordered eating.[5,6] Female athletes who develop disordered eating habits are also at risk of being diagnosed with a relative energy deficit syndrome. Consequences of this syndrome include stress fractures, lower bone mass, and slow healing time.[7,8] These factors suggest the importance of identifying and treating disordered eating in the female adolescent athlete population, particularly on injury onset.

A body mass index (BMI) at or below the second percentile or a gradual drop from a healthy BMI to an underweight BMI is one of many indicators of disordered eating in children and adolescents.[9] Previous research has not explored whether female pediatric and adolescent patients experience a clinically relevant postoperative decrease in BMI after sports or trauma surgery. With the prevalence of eating disorders increasing in adolescence and the rise in sport participation, increasing numbers of patients may be at risk to develop disordered eating after injury.[10] The use of BMI, a measurement made at most clinical visits, could provide surgeons with a quick and effective screening tool to flag postoperative patients with potential disordered eating.

The purpose of this study was to identify whether adolescent females are more prone to postoperative BMI decreases when compared to other female age groups (school-age and preadolescent) and all male age groups. The investigators hypothesized that pediatric female patients would experience a statistically significant postoperative decrease in BMI after upper or lower extremity sports or trauma surgery when compared to male patients. Additionally, adolescent (age 15-19 inclusive) and pre-adolescent females (age 11-14 inclusive) would be more prone to postoperative BMI changes than school-age female patients (age 5-10 inclusive) and male patients across all age groups.

Methods

A list of the 50 most frequently used new diagnosis codes (ICD-10) from January 1, 2019, to January 1, 2021, from two pediatric orthopaedic surgeons at an orthopaedic hospital was generated from our institution's electronic health record (EPIC, Verona, WI). Diagnoses that did not require surgery were excluded. The subsequent list of 17 diagnoses (Table 1) was expanded to include all associated ICD-10 codes. The final list of diagnosis codes included 402 unique encounter IDs.

A list of 485 patients who underwent surgery between 2016-2020 who had one of the 17 diagnoses was generated. Patients subsequently were excluded if they were below the age of 5, above the age of 19, or had multiple surgeries. The final patient list included 156 patients with their surgery dates anchoring two BMI data points: baseline (measurement closest to the date of pre-surgery) and postoperative (2-8 months post-surgery). Missing data was obtained from patients' growth charts,

Table 1. The 17 Diagnoses Used for Patient Identification

Injury Type
1. Sprain of Anterior Cruciate Ligament
2. Shoulder Instability
3. Unspecified Fracture of Forearm
4. Meniscus Tear
5. Recurrent Subluxation of Patella
6. Fracture of Shaft of Ulna
7. Supracondylar Fracture
8. Supracondylar Fracture Without Intercondylar Fracture of Humerus
9. Unspecified Dislocation of Right Shoulder Joint
10. Unspecified Fracture of Ulna
11. Superior Glenoid Labrum Lesion of Shoulder
12. Displaced Fracture (Avulsion) of Medial Epicondyle
13. Nondisplaced Spiral Fracture of Tibia
14. Unspecified Fracture of Radius
15. Displaced Simple Supracondylar Fracture
16. Displaced Fracture of Clavicle
17. Sprain of Medial Patellofemoral Ligament

acquired from EPIC and the patients' primary care physicians. Demographic data was also collected for all patients including sex, race, ethnicity, and age.

All 156 patients were included in the statistical analysis (Figure 1). Patients were divided into cohorts by age: school-age (5-10 inclusive), pre-adolescent (11-14 inclusive), and adolescent (15-19 inclusive). The primary outcome was a BMI difference score, obtained by subtracting the postoperative from the preoperative BMI values for all patients. A one-way ANOVA was used to test for any differences in BMI change among age groups. Three independent samples t-tests were used to analyze BMI change by gender for each age cohort. Descriptive statistics were reported using means and standard deviations for continuous variables, while frequencies and percentages were used to report discrete

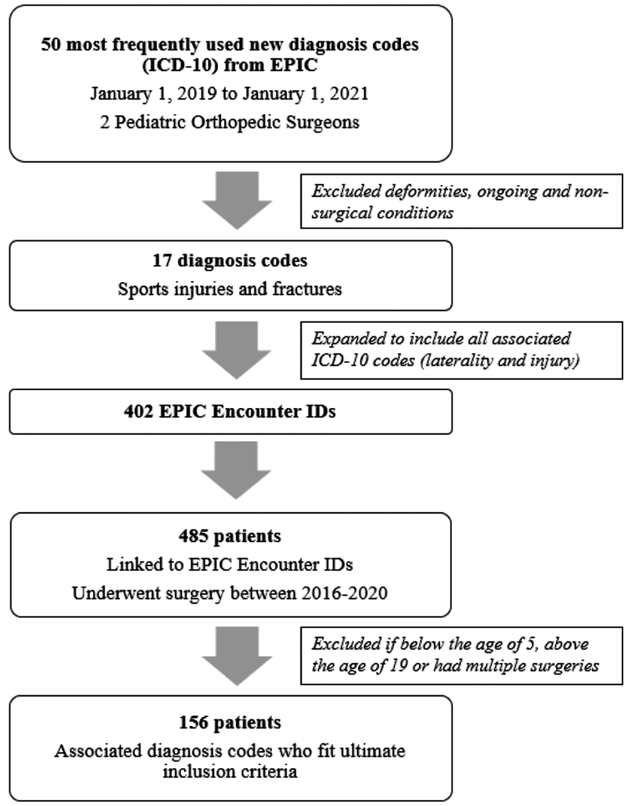

Figure 1. *Retrospective chart review patient list generation.*

variables. Statistical analysis was performed on IBM SPSS Statistics Version 22 for PC.

Results

A total of 156 patients were included in the statistical analysis, with a mean age of 13.3 +/- 2.9 years at the time of surgery. Seventy (44.9%) patients were female and 86 (55.1%) were male. Most of the patients were White (70.5%) and not Hispanic (84.0%). Twenty-four patients were categorized as school-aged (5-10 inclusive), 72 as pre-adolescent (11-14 inclusive), and 60 as adolescent (15-19 inclusive) (Table 2). Postoperative BMI was taken at a mean follow-up of 2.8±2.0 months with no difference between age cohorts (p=0.218).

There was not a statistically significant difference in BMI change between age groups as determined by one-way ANOVA (p=0.86). The mean difference between pre- and postoperative BMI scores for the school-age, pre-adolescent and adolescent groups were -0.05, -0.15 and

Table 2. Patient Demographic Data Broken Down by Age Cohort

	Total		School-Age (5-10)		Pre-Adolescent (11-14)		Adolescent (15-19)	
Variable:	**Number**	**Percent (%)**	**Number**	**Percent (%)**	**Number**	**Percent (%)**	**Number**	**Percent (%)**
Patients:	156	100	24	15.4	72	46.2	60	38.5
Race:								
White	110	70.5	13	54.2	57	79.2	40	66.7
Asian	10	6.4	1	4.2	4	5.6	5	8.3
Black or African American	6	3.8	1	4.2	1	1.4	4	6.7
>1 Race indicated	2	1.3	1	4.2	0	0	1	1.7
Other	14	9	4	16.7	3	4.2	7	11.7
Not Recorded	14	9	4	16.7	7	9.7	3	5
Ethnicity:								
Hispanic	13	8.3	5	20.8	3	4.2	5	8.3
Non-Hispanic	131	84	16	66.7	64	88.9	51	85
Not Recorded	12	7.7	3	12.5	5	6.9	4	6.7
Sex:								
Male	86	55.1	14	58.3	37	51.4	35	58.3
Female	70	44.9	10	41.7	35	48.6	25	41.7
	Mean	**Standard Deviation (SD)**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Follow-up Visit time (months)	2.8	2.0	2.6	1.9	2.6	2.0	3.2	1.9
Preoperative BMI	20.9	4.4	17.4	3.6	20.6	4.3	22.7	4.1
Postoperative BMI	21	4.6	17.5	3.7	20.7	4.5	22.8	4.1

-0.08, respectively. Within age groups, differences for BMI difference by gender were not significant (school-age (p=0.36), pre-adolescent (p=0.26), adolescent (p=0.43)) (Figure 2). The within age group sample sizes were approximately equivalent.

Discussion

This study sought to identify whether adolescent females who sustain sports injuries or fractures are more prone to postoperative BMI decreases when compared to other age groups or male patients. Our analysis found no significant postoperative changes in BMI between males and females over the time intervals measured. Children who develop eating disorders have been shown to follow specific BMI trajectories prior to diagnosis[9,11,12]; however, not all children present with these BMI changes. While BMI change is a potential indicator of disordered eating, it may be insensitive to detect certain changes in eating habits. Further research focused on subtle changes in eating habits is necessary to determine if eating disorders develop without BMI changes following surgical intervention. The use of PROMs

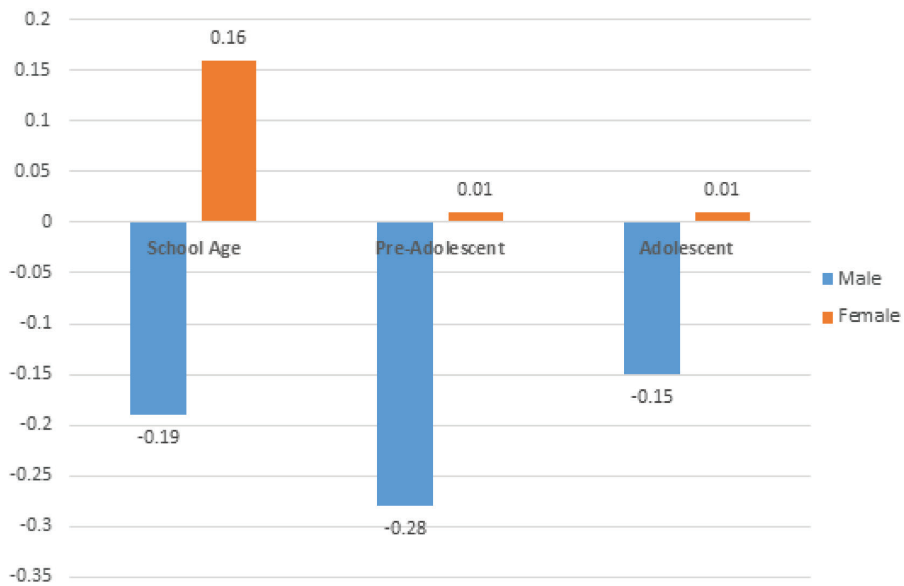

Figure 2. *Mean BMI difference by age cohort.*

specifically focused on body image and mental health could also provide additional information not captured in BMI measurements for future studies.

Disordered eating is more prevalent among athletes than non-athletes[13] and eating disorders have been found to be most prevalent among female athletes who specialize in sports where low body weight or leanness offers a competitive advantage.[14] In a study examining an athletic population, approximately 20% of females were found to suffer from eating disorders compared to only 9% of female controls.[13] In males, 8% of athletes met criteria for eating disorders, while only 0.5% of controls met criteria.[13] In the present study, there was no significant difference in BMI change after surgery among age groups (p=0.86). However, further studies analyzing BMI changes by specific sport may help to highlight patients at risk for developing eating disorders following surgical intervention.

Many studies have focused on identifying risk factors for the development of eating disorders, specifically in collegiate athletes,[15,16] with findings highlighting factors such as performance pressure, bullying, and puberty. A study including 522 elite female athletes and 448 non-athlete controls showed that 18% of the athlete cohort met criteria for eating disorders after completing clinical examination, standardized questionnaires, and interviews. In contrast, just 5% of non-athlete controls met eating disorder criteria.[17] Female athletes who develop disordered eating habits are also at risk of being diagnosed with a relative energy deficit syndrome which includes disordered eating, amenorrhea, and osteopenia. Consequences of this syndrome include stress fractures, lower bone mass, and slow healing time.[7,8] The frequency of eating disorders among the female adolescent athlete population highlights the importance of further literature on the subject. Disordered eating habits can have devastating effects on athlete performance and physical health that can both increase the likelihood of injury and slow recovery time.[18-21]

This investigation utilized BMI measurements made at surgical follow-ups and primary care physician visits to analyze whether patients experienced a postoperative decrease in BMI, which could indicate disordered eating habits after injury. Children who develop eating disorders have been shown to follow specific BMI trajectories prior to diagnosis (either BMI decrease or low BMI compared to developmental norms).[22-24] A BMI in the 2nd percentile or lower or a gradual drop from a healthy BMI to an underweight BMI might indicate disordered eating.[11] A study of 1,640 women and 794 men found that clinically relevant weight loss indicating disordered eating could be as little as a 5% decrease in BMI. At the 5% definition, combined with cognitive concerns, anorexia was associated with elevated eating pathology and distress relative to controls.[12] Although the results of this study do not indicate a significant decrease of BMI among patients, surgeons should still be attentive to this risk following sports or trauma surgery given the literature. It is known that a clinically significant drop in BMI alone does not indicate disordered eating in patients, but it might be cause for further examination and questionnaires to rule out a disordered eating diagnosis.[22-24]

There are several limitations to this study. First, the retrospective nature of the study posed some unforeseen constraints given the COVID-19 pandemic. Some patients had missing BMI measurements for surgical follow-up visits. Many patients did not come to the hospital for postoperative appointments due to pandemic restrictions. Instead, they were seen via telehealth video visits. In order to minimize the effect of this limitation, the investigators contacted primary care physicians and requested patient growth chart data. While the use of these growth charts provided further data points, it introduced more variability in the weighing process. Future research should seek to answer this question prospectively to avoid gaps in the data and help standardize the weighing process. Furthermore, the COVID-19 pandemic itself caused many changes to people's lifestyles and could therefore cause weight loss or gain depending on these lifestyle modifications. Additionally, BMI is not always indicative of disordered eating. According to the DSM-V, eating disorder diagnoses in children and adolescents are made using a combination of indications: underweight (BMI <18.5), self- or parent-reported weight and shape concern, engagement in fasting for weight loss or to avoid weight gain at least monthly, or engagement in excessive exercise.[25] These factors usually are assessed by a combination of tools, including patient and parent questionnaires, psychological evaluation, and physical exam; however, they are not always utilized when an athlete is injured.[26] To address this limitation, the authors do not suggest that a clinically significant drop in BMI could indicate disordered eating, but simply that it might be cause for concern among surgeons who witness a drop after surgery. Third, 2-8 months may not be a long enough window after surgery to show a clinically relevant BMI decrease. Future research should assess BMI differences with a longer follow-up time. Finally, with patients coming in for a variety of surgical follow-ups, some may be wearing casts or braces which adds to their weight, while others are not or may be asked to remove them for the weight check. While this may cause some differences in BMI, the authors believe that since the large majority of measurements were made at the same orthopaedic clinic, these differences are minimal and do not negate the findings.

In conclusion, the results of this study do not indicate that a specific sex or age demographic is at particular risk of BMI decline following sports or trauma surgery; however, surgeons should still be attentive to this risk given prior literature on the topic. While a drop in BMI alone may not indicate disordered eating, the literature suggests it may be cause for further examination.[22-24] With the prevalence of eating disorders growing and the rise in sport participation and specialization among pediatric and adolescent patients, increasing numbers of patients may be at risk of developing disordered eating habits.[1,2] Future research should investigate more directly and prospectively whether pediatric and adolescent patients experience disordered eating after sports or trauma surgery using a variety of metrics, such as patient and parent questionnaires.

Disclaimer

A. Mackie, N. Pascual-Leone, F. Coxe: No conflicts of interest to disclose; P. Fabricant: *Clinical Orthopaedics and Related Research*: Editorial or governing board, Pediatric Orthopaedic Society of North America: Board or committee member, Pediatric Research in Sports Medicine Society: Board or committee member. Research in OsteoChondritis of the Knee (ROCK): Board or committee member; S. Doyle: Reviewer for *Journal* *of Pediatric Orthopaedics* and *Journal of American Academy of Orthopaedic Surgeons.*

References

1. Arthur-Cameselle J, Sossin K, Quatromoni P. A qualitative analysis of factors related to eating disorder onset in female collegiate athletes and non-athletes. *Eat Disord*. 2017;25(3):199-215.
2. Daley MM, Griffith K, Milewski MD, et al. The mental side of the injured athlete. *J Am Acad Orthop Surg*. 2021;29(12):499-506.
3. Beals KA. Eating disorder and menstrual dysfunction screening, education, and treatment programs: survey results from NCAA division 1 schools. *Phys Sportsmed*. 2003;31(7):33-38.
4. Beals RL. Fifty years in anthropology. *Annu Rev Anthropol*. 1982;11(1):1-24.
5. Kotler LA, Cohen P, Davies M, et al. Longitudinal relationships between childhood, adolescent, and adult eating disorders. *J Am Acad Child Adolesc Psychiatry.* 2001;40(12):1434-1440.
6. Vohs KD, Heatherton TF, Herrin M. Disordered eating and the transition to college: a prospective study. *Int J Eat Disord*. 2001;29(3):280-288.
7. Yeager KK, Agostini R, Nattiv A, et al. The female athlete triad: disordered eating, amenorrhea, osteoporosis. *Med. Sci. Sports Exerc*. 1993;25(7):775-777.
8. Otis CL, Drinkwater B, Johnson M, et al. ACSM position stand: the female athlete triad. *Med. Sci. Sports Exerc*. 1997;29(5):i-ix.
9. Nicholls D, Viner R. Eating disorders and weight problems. *BMJ*. 2005;330(7497):950-953.
10. Herpertz-Dahlmann B. Adolescent eating disorders. *Child Adolesc Psychiatr Clin N Am*. 2015;24(1):177-196.
11. Forney KJ, Brown TA, Holland-Carter LA, et al. Defining “significant weight loss” in atypical anorexia nervosa: Forney et al. *Int J Eat Disord*. 2017;50(8):952-962.
12. Williamson DA, Bray GA, Ryan DH. Is 5% weight loss a satisfactory criterion to define clinically significant weight loss?: “Clinically Meaningful” Weight Loss. *Obesity*. 2015;23(12):2319-2320.
13. Sundgot-Borgen J, Torstveit MK. Prevalence of eating disorders in elite athletes is higher than in the general population. *Clin J Sport Med*. 2004;14(1):25-32.
14. Joy E, Kussman A, Nattiv A. 2016 update on eating disorders in athletes: a comprehensive narrative review with a focus on clinical assessment and management. *Br J Sports Med*. 2016;50(3):154-162.
15. McDonald AH, Pritchard M, McGuire MK. Self-reported eating disorder risk in lean and non-lean NCAA Collegiate Athletes. *Eat Weight Disord*. 2020;25(3):745-750.
16. Reinking MF, Alexander LE. Prevalence of disordered-eating behaviors in undergraduate female collegiate athletes and nonathletes. *J Athl Train*. 2005;40(1):47-51.
17. Sundgot-Borgen J. Prevalence of eating disorders in elite female athletes. *Int J Sport Nutr*. 1993;3(1):29-40.
18. Tenforde AS, Fredericson M, Sayres LC, et al. Identifying sex-specific risk factors for low bone mineral density in adolescent runners. *Am J Sports Med*. 2015;43(6):1494-1504.
19. El Ghoch M, Soave F, Calugi S, Dalle Grave R. Eating disorders, physical fitness and sport performance: a systematic review. *Nutrients*. 2013;5(12):5140-5160.
20. VanHeest JL, Rodgers CD, Mahoney CE, et al. Ovarian suppression impairs sport performance in junior elite female swimmers. *Med Sci Sports Exerc*. 2014;46(1):156-166.
21. Tenforde AS, Sayres LC, McCURDY ML, et al. Identifying sex-specific risk factors for stress fractures in adolescent runners. *Med Sci Sports Exerc*. 2013;45(10):1843-1851.
22. Yilmaz Z, Gottfredson NC, Zerwas SC, et al. Developmental premorbid body mass index trajectories of adolescents with eating disorders in a longitudinal population cohort. *J Am Acad Child Psychiatry.* 2019;58(2):191-199.
23. Smith FM, Latchford G, Hall RM, et al. Indications of disordered eating behaviour in adolescent patients with idiopathic scoliosis. *J Bone Joint Surg Br*. 2002;84-B(3):392-394.
24. Boyd HK, Bodell LP, Jennings KM, et al. Relationship between desired weight constructs and eating disorder severity following treatment for anorexia nervosa. *Int J Eat Disord*. 2018;51(8):870-878.
25. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. American Psychiatric Association, 2013.
26. Knapp J, Aerni G, Anderson J. Eating disorders in female athletes: use of screening tools. *Curr Sports Med Rep*. 2014;13(4):214-218.