Published in final edited form as:
Ambul Pediatr. 2008 ; 8(1): 66–69.

The Association of Overweight and Ankle Injuries in Children

Mark R. Zonfrillo, MD, **Jeffrey A. Seiden, MD**, **Ellen M. House, BS**, **Eugene D. Shapiro, MD**, **Robert Dubrow, MD, PhD**, **M. Douglas Baker, MD**, and **David M. Spiro, MD, MPH**

From the Department of Pediatrics (Drs Zonfrillo, Seiden, Shapiro, Baker, Spiro and Ms House) and Department of Epidemiology and Public Health (Drs Shapiro and Dubrow), Yale University School of Medicine, New Haven, Connecticut.Drs Zonfrillo and Seiden are now with the Division of Emergency Medicine, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania. Dr Baker is now with the Department of Pediatrics, University of Texas Southwestern Medical Center, Dallas, Texas. Dr Spiro is now with the Departments of Emergency Medicine and Pediatrics, Oregon Health and Science University, Portland, Oregon

Abstract

OBJECTIVES—Overweight children are at increased risk for many medical problems. Trauma is the leading etiology of childhood morbidity and mortality. No previous study has evaluated the association between overweight and acute ankle injuries in children. We hypothesized that being overweight is associated with an increased risk of ankle injury in children.

METHODS—We conducted a case-control study in an urban pediatric emergency department. Subjects aged 5 to 19 years were recruited from June 2005 through July 2006. Children with acute ankle trauma were enrolled as cases. A convenience sample of children with a chief complaint of fever, headache, or sore throat was enrolled as controls. Demographic information and anthropometric measurements were obtained. Age- and gender-specific body mass index percentiles (BMI-Ps) were calculated using pediatric norms.

Multivariate unconditional logistic regression was used to assess the relationship between overweight and ankle injury, adjusting for demographic variables. Through medical records, we obtained demographic information and weight, but not height, of all cases who were not enrolled. This allowed us to conduct a sensitivity analysis in which we combined the enrolled and non-enrolled cases into a single case group and made increasingly more unlikely assumptions about the height percentiles of the non-enrolled cases.

RESULTS—There were 180 cases and 180 controls enrolled in the study. We observed a significant association between overweight and ankle injury (multivariate-adjusted OR: 3.26; 95% CI: 1.86–5.72; P value for trend <.0001). Although this result may be an overestimate of the magnitude of the association due to a possible bias in the selection of cases, sensitivity analysis demonstrated the robustness of the statistical significance of the finding.

CONCLUSIONS—Overweight children may be at increased risk of ankle injury.

Keywords

ankle injuries; overweight; pediatrics

Address correspondence to Mark R. Zonfrillo, MD, Department of Pediatrics, Division of Emergency Medicine, University of Pennsylvania School of Medicine, The Children's Hospital of Philadelphia, 34th Street and Civic Center Boulevard, Philadelphia, PA 19104, Phone: 267-426-0294, Fax: 215-590-4454, E-mail: zonfrillo@email.chop.edu.

Disclosures: The authors have no conflicts of interest or corporate sponsorship.

INTRODUCTION

Childhood obesity has become a global epidemic with more than 155 million overweight children worldwide.[1] In the United States, 34% of children are categorized as being overweight (body mass index percentile [BMI-P] ≥95) or at risk for overweight (BMI-P ≥85 to <95). [2] Moreover, the prevalence of overweight among children and adolescents has nearly tripled over the past two decades.[3] Overweight children are at increased risk for many medical problems, which may continue through adulthood.[4]

Trauma is the most common cause of childhood morbidity and mortality. In the United States more children die from injuries than from all other conditions combined. In 2004 more than 9 million non-fatal injuries occurred in children and adolescents,[5] 4% of which were ankle injuries.[6] Ankle injuries can result in more long-term lifestyle-limiting disability than commonly perceived.[7, 8]

Despite the increase in childhood obesity and the high prevalence of trauma in childhood, relatively few studies have been conducted to assess the relationship between the two. A cross-sectional survey of 9 to 17 year old children based on self-report showed an association between obesity and the occurrence of injuries,[9] and a chart review of the records of children and adolescents found an association between overweight orthopedic difficulties, including musculoskeletal discomfort and impaired mobility.[10] The combination of increased body mass and previous ankle sprain is associated with a higher risk of subsequent sprains in high school athletes.[11] Both adults and children who sustain an ankle injury and are obese are likely to have greater long-term ankle morbidity than their normal weight counterparts.[12, 13] The current literature demonstrates a clear increased risk for the occurrence and morbidity of many different injuries in obese individuals.

We hypothesize that children who are overweight have an increased risk of ankle injury. To our knowledge, no previous study has examined the relationship between overweight and the occurrence of ankle injury in a general population of children.

METHODS

Study Design

This was a case-control study, which was approved by our institution’s Human Investigation Committee. The need for written informed consent was waived. Verbal consent was obtained from caretakers (or patients 18 years or older), and verbal assent was obtained from patients younger than age 18 years, at the time of enrollment. The families were told that we were conducting a study looking at the relationship between ankle injuries and obesity.

Study Setting and Population

This study was conducted from June 2005 to July 2006. Cases and controls were children aged 5 to 19 years presenting to an urban pediatric emergency department (PED) with approximately 31,000 yearly visits. Cases were children with a chief complaint of acute ankle injury, defined by any musculoskeletal trauma to the ankle while ambulatory. PED physicians were asked to recruit cases consecutively, twenty-four hours a day. Controls were children who presented during this same time period with a chief complaint of fever, headache, or sore throat. Controls were enrolled consecutively as a convenience sample during shifts (between 8am and midnight) when a research associate was available in the PED. Exclusion criteria for cases and controls included inability to obtain weight or height, previous enrollment, and primary language other than English or Spanish. Exclusion criteria for the cases included non-accidental trauma and final diagnosis other than an ankle injury.

Study Protocol

Information was collected for all recruited subjects on gender, age, race/ethnicity, and insurance status. Weight and height were measured using an electronic scale and stadiometer with study participants in street clothes. Age- and gender-specific BMI-Ps, weight percentiles (Wt-Ps), and height percentiles (Ht-Ps) were calculated using the Centers for Disease Control and Prevention pediatric growth charts.[14, 15]

Our intent was to approach for recruitment all ankle injury patients. However, in practice, many patients were not approached during times when the emergency department was particularly busy. Consequently, we used our computerized medical record system (Lynx, Lynx Medical Systems, Bellevue, WA) to identify all nonparticipant cases (patients with ankle injuries who were not recruited into the study). Through chart review, we collected information for these nonparticipants on gender, age, race/ethnicity, insurance status, and weight, but information on height was not available. Wt-Ps, but not Ht-Ps or BMI-Ps (due to the lack of information about height), were calculated for these nonparticipants.

Data Analysis

We used the standard categorizations of BMI-P ≥95% as overweight, BMI-P ≥85 to <95 as at risk for overweight, and BMI-P <85 as normal weight.[2]

Characteristics of cases and controls, as well as cases and nonparticant cases, were compared using frequency distributions (chi-square test) and means (t-test). Multivariate unconditional logistic regression was used to calculate multivariate-adjusted odds ratios (ORs) as estimates of relative risk, along with the corresponding 95% confidence intervals (CIs), for ankle injury cases compared with controls in relation to overweight and at risk for overweight, using normal weight children as the reference group. The adjustment variables in the models were age, gender, race/ethnicity, insurance status, and month of admission. Month of admission was included as an adjustment variable because there was some imbalance in the month of admission of cases compared to controls, and we were concerned that BMI-P might be associated with season. To test for the significance of the linear trend, we included BMI-P category as an ordinal variable (the three levels being normal weight, at risk for overweight, and overweight) in a multivariate logistic regression model. The P value for trend was derived from the likelihood ratio statistic. We considered P values < .05 to be statistically significant.

We compared the prevalences of overweight and at risk for overweight among the controls with those expected according to national estimates by calculating standardized prevalence ratios (SPRs) using age-, gender-, and race/ethnicity-specific prevalence estimates for 2003–2004 from the National Health and Nutrition Examination Survey[2] as the standard. A SPR of 1.0 indicates that the prevalence among the controls was the same as the national prevalence.

RESULTS

Participants

During the study period, 323 unique patients with ankle injuries due to accidental trauma were seen at the PED. Of those, 180 cases (55.7%) were recruited by physicians to participate in the study. There were 180 controls recruited, with only two refusals. The case group was similar to the control group with respect to race/ethnicity and month of admission (Table 1). However, cases were older than (P < .0001), more frequently male than (P = .09), and more likely to have private insurance than (P = .06) controls (Table 1).

The prevalences of overweight and at risk for overweight among the controls were similar to the expected prevalences based on national estimates (SPR = 1.04 for overweight and 1.09 for at risk for overweight).

Outcomes

Cases were significantly more overweight than controls, as measured by mean BMI-P (P =. 0001) and by BMI-P category distribution ($P < .001$) (Table 1). The multivariate analysis demonstrated a significant association between overweight and ankle injury (multivariate-adjusted OR: 3.26; 95% CI: 1.86–5.72) and a significant trend of increasing risk of ankle injury with increasing BMI-P category ($P < .0001$) (Table 2).

The mean weight percentile of cases was higher than that of the nonparticipant cases identified through medical records (79.4±23.9 versus 74.0±25.2; P =.05), suggesting a possible bias toward selection of overweight children into the participant case group. (We are not certain that such a bias occurred because we did not know the heights of the nonparticipant cases.)

To assess this possible bias, we combined the 180 participant cases and the 143 nonparticipant cases into a single case group (N = 323). We then performed a sensitivity analysis in which we calculated multivariate-adjusted ORs for overweight in relation to ankle injury using increasingly more unlikely assumptions about the height percentiles of the nonparticipant cases in the direction that would attenuate the association. Thus, if we assumed that the all the nonparticipant cases were in the 58^{th} height percentile (similar to the participant cases and controls – Table 1), the multivariate-adjusted OR was 2.63 (95% CI: 1.63–4.24; P value for trend < .0001). The following are the results for increasingly more unlikely assumptions: 75^{th} height percentile (multivariate-adjusted OR: 2.23; 95% CI: 1.38–3.61; P value for trend < .001); 85^{th} height percentile (multivariate-adjusted OR: 2.07; 95% CI: 1.28–3.34; P value for trend = .003); 90^{th} height percentile (multivariate-adjusted OR: 1.97; 95% CI: 1.22–3.18; P value for trend = .006); and 95^{th} height percentile (multivariate-adjusted OR: 1.79; 95% CI: 1.11–2.89; P value for trend = .02).

DISCUSSION

We observed a significant association between overweight and ankle injury (multivariate-adjusted OR: 3.26; 95% CI: 1.86–5.72; P value for trend <.0001). Although this result may be an overestimate of the magnitude of the association due to a possible bias toward selection of overweight cases (presumably due to the physician recruiters knowing the study hypothesis), sensitivity analysis demonstrated the robustness of the statistical significance of the finding. Thus, even under the highly unlikely assumption that all the nonparticipant cases were in the 95^{th} height percentile, the multivariate-adjusted OR would have been 1.79, with a 95% CI of 1.11–2.89 and P value for trend of .02. Because we did not know the heights of the nonparticipant cases, we are not certain that a selection bias did occur. However, we conservatively estimate that the risk of ankle injury in overweight children is at least two-fold greater than the risk in normal weight children.

It does not appear that this result could be explained by any other bias. Bias in the selection of the control group is unlikely because the prevalences of overweight and at risk for overweight among the controls were similar to the prevalences expected according to national estimates. Because controls were not recruited from midnight to 8 am, there may have been a difference between cases and controls with regard to time of day of emergency department visit. However, most ankle injuries occur and are triaged during ‘waking hours,’ suggesting that this difference would have been small. Finally, although it is possible that children with ankle injuries who present to the emergency department are more overweight than those who do not, we know of no evidence in favor of this hypothesis.

There are a few possible mechanisms that could explain the increased risk of ankle injuries in overweight children. That the ankle bears more weight in overweight compared to normal weight children may increase the risk of ankle injury among the overweight. In addition, poor balance, objectively measured as unstable postural sway, has been identified as a risk factor in ankle injuries,[16] and overweight male adolescents have poorer single-limb stance balance than normal weight individuals.[17] However, the exact biomechanics of childhood injuries in the overweight is largely unknown and requires further investigation.[18] In particular, it may be useful to study the association of overweight with other known risk factors for ankle injuries, such as limited dorsiflexion and impaired proprioception.[19] Additionally, it may be useful to examine the association of overweight and ankle injury severity. However, this is difficult as pediatric ankle injuries are complex and difficult to classify objectively.[20]

CONCLUSIONS

This is the first study in an emergency department setting to describe that overweight children may have an increased risk of ankle injuries. Additional studies should explore the risk of other specific childhood injuries in overweight children, the association of overweight and injury severity, and the biomechanics of these associations. Our new findings may have implications for prevention and management of minor childhood trauma and obesity in the emergency department.

Acknowledgements

Grant Support: The research for this study was funded by the American Academy of Pediatrics Resident Research Grant awarded to Dr. Mark Zonfrillo, and grants RR022477 and M01-RR00125 from the National Institutes of Health awarded to Dr. Eugene Shapiro.

We would like to thank the staff at the Yale-New Haven Children's Hospital Pediatric Emergency Department for all of their support.

References

1. Lobstein T, Baur L, Uauy R. Obesity in children and young people: a crisis in public health. Obes Rev May 2004;5 (Suppl 1):4–104.
2. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA Apr 5;2006 295(13):1549–1555. [PubMed: 16595758]
3. Flegal KM. Epidemiologic aspects of overweight and obesity in the United States. Physiol Behav Dec 15;2005 86(5):599–602. [PubMed: 16242735]
4. Reilly JJ, Methven E, McDowell ZC, et al. Health consequences of obesity. Arch Dis Child Sep 2003;88 (9):748–752.
5. Centers for Disease Control-National Center for Injury Prevention and Control. [Accessed August 27, 2006]. Available at: http://webappa.cdc.gov/sasweb/ncipc/nfirates2001.html
6. National Electronic Injury Surveillance System (NEISS). [Accessed September 1, 2006]. Available at: http://www.cpsc.gov/library/neiss.html
7. Braun BL. Effects of ankle sprain in a general clinic population 6 to 18 months after medical evaluation. Arch Fam Med Mar–Apr 1999;8(2):143–148.
8. Gerber JP, Williams GN, Scoville CR, Arciero RA, Taylor DC. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. Foot Ankle Int Oct 1998;19(10): 653–660.
9. Bazelmans C, Coppieters Y, Godin I, et al. Is obesity associated with injuries among young people? Eur J Epidemiol 2004;19(11):1037–1042. [PubMed: 15648597]
10. Taylor ED, Theim KR, Mirch MC, et al. Orthopedic complications of overweight in children and adolescents. Pediatrics Jun 2006;117(6):2167–2174.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

11. Tyler TF, McHugh MP, Mirabella MR, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school football players: the role of previous ankle sprains and body mass index. Am J Sports Med Mar 2006;34(3):471–475.
12. Bostman OM. Body-weight related to loss of reduction of fractures of the distal tibia and ankle. J Bone Joint Surg Br Jan 1995;77(1):101–103.
13. Timm NL, Grupp-Phelan J, Ho ML. Chronic ankle morbidity in obese children following an acute ankle injury. Arch Pediatr Adolesc Med Jan 2005;159(1):33–36.
14. Ellis, RW. Body mass index percentile for age calculator. Available at: http://www.mamc.amedd.army.mil/clinical/standards/childhood_obesity_pro.htm
15. Centers for Disease Control-National Health and Nutrition Examination Survey. [Accessed August 27, 2006]. Available at: http://www.cdc.gov/growthcharts
16. Wang HK, Chen CH, Shiang TY, Jan MH, Lin KH. Risk-factor analysis of high school basketball-player ankle injuries: a prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. Arch Phys Med Rehabil Jun 2006;87(6):821–825.
17. Goulding A, Jones IE, Taylor RW, Piggot JM, Taylor D. Dynamic and static tests of balance and postural sway in boys: effects of previous wrist bone fractures and high adiposity. Gait Posture Apr 2003;17(2):136–141.
18. Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP. The impact of childhood obesity on musculoskeletal form. Obes Rev May 2006;7(2):209–218.
19. de Noronha M, Refshauge KM, Herbert RD, Kilbreath SL, Hertel J. Do voluntary strength, proprioception, range of motion, or postural sway predict occurrence of lateral ankle sprain? Br J Sports Med Oct;2006 40(10):824–828. [PubMed: 16920769]discussion 828
20. Marsh JS, Daigneault JP. Ankle injuries in the pediatric population. Curr Opin Pediatr Feb 2000;12 (1):52–60.

Table 1

Baseline Characteristics of Cases and Controls

Characteristic	Cases (*N* = 180)	Controls (*N* = 180)	*P* value
Male sex, *n* (%)	105 (58.3)	89 (49.4)	.09
Age in years, mean (SD)	13.7 (3.0)	11.6 (4.1)	<.0001
Race/ethnicity, *n* (%)			.82
White	58 (32.2)	63 (35.0)	
Black	67 (37.2)	70 (38.9)	
Hispanic	51 (28.3)	44 (24.4)	
Other	4 (2.2)	3 (1.7)	
Insurance[*], *n* (%)			.06
Private	84 (46.7)	62 (34.6)	
Medicaid	80 (44.4)	94 (52.5)	
Other	16 (8.9)	23 (12.8)	
Month of admission, *n* (%)			.29
January – March	35 (19.4)	48 (26.7)	
April – June	37 (20.6)	28 (15.6)	
July – September	65 (36.1)	67 (37.2)	
October – December	43 (23.9)	37 (20.6)	
BMI percentile†			<.001
<85	75 (41.7)	109 (60.6)	
≥85 – <95[‡]	40 (22.2)	35 (19.4)	
≥95[§]	65 (36.1)	36 (20.0)	
BMI percentile, mean (SD)	80.1 (23.2)	69.7 (26.6)	.0001
Weight percentile			.001
<85	73 (40.6)	105 (58.3)	
≥85 – <95	46 (25.6)	41 (22.8)	
≥95	61 (33.9)	34 (18.9)	
Weight percentile, mean (SD)	79.4 (23.9)	70.3 (26.3)	<.001
Height percentile			.78
<85	128 (71.1)	133 (73.9)	
≥ 85 – <95	29 (16.1)	28 (15.6)	
≥ 95	23 (12.8)	19 (10.6)	
Height percentile, mean (SD)	57.2 (30.7)	57.8 (29.8)	.84

[*] N = 179 for controls due to a missing value.

[‡] At risk for overweight.

[§] Overweight.

Table 2

Multivariate-adjusted odds ratios for ankle injuries in relation to overweight and at risk for overweight

BMI Percentile	Cases (N=180)	Controls (N=180)[†]	Multivariate-adjusted odds Ratio (95% CI)
<85 (Normal weight)	75	109	1.00
≥ 85 - <95 (At risk for overweight)	40	35	1.73 (0.95–3.14)
≥ 95 (Overweight)	65	36	3.26 (1.86–5.72)
***P*-value for trend**			<.0001

[*] Adjusted for age, gender, race/ethnicity, insurance status and month of visit.

[†] N=179 controls in the multivariate analysis due to a missing value for insurance status.