Childhood Obesity is Associated With Osteochondritis Dissecans of the Knee, Ankle, and Elbow in Children and Adolescents

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Background: Osteochondritis dissecans (OCD) is a joint disorder of the subchondral bone and articular cartilage whose association with obesity in children is not clearly known. The purpose of this study was to assess the magnitude of the association between childhood obesity and the occurrence of OCD of the knee, ankle, and elbow in children.

Methods: A retrospective chart review of an integrated health system was performed on OCD patients aged 2 to 19 from 2007 to 2011, with over 1 million patients in this cohort. Lesion location, laterality, and all patient demographics were recorded. The body mass index (BMI) for each patient in the cohort was used to stratify patients into 5 weight classes (underweight, normal weight, overweight, moderately obese, and extremely obese) based on BMI-for-age. The associations between the 5 weight classes and OCD of the ankle, knee, and elbow were assessed using multiple logistic regression models to estimate odds ratios (OR) and 95% confidence intervals using multivariate analysis to adjust for patient demographic variables.

Results: In total, 269 patients fit the inclusion criteria. Mean BMI, both absolute and percentile, was significantly higher for patients with OCD of the knee, elbow, and ankle than patients without OCD. In the multivariate analysis, extremely obese patients were found to have an increased OR of OCD for all patients, with an 86% increased risk of any OCD compared with normal weight patients. In addition, assessment by different types of OCD revealed that extremely obese patients had an increased OR of OCD of the elbow and ankle individually, with a 3.1 times increased OCD elbow risk and 3.0 times increased risk of ankle OCD in extremely obese patients. Although extremely obese patients did not have a statistically significant increased risk of knee OCD, moderately obese patients did have a 1.8 times increased risk of knee OCD as compared with normal weight children. There were no significantly different risks of any type of OCD seen in overweight or underweight patients as compared with normal weight patients.

Conclusions: In this population-based cohort study, extreme obesity is strongly associated with an increased risk of OCD overall and OCD of the elbow and ankle specifically. In addition, moderate obesity is associated with an increased risk of knee OCD. All types of OCD were also found to have a significantly greater average BMI when compared with patients without OCD.

Level of Evidence: Level IV—descriptive epidemiology study.

Key Words: osteochondritis dissecans, OCD, BMI, obesity, pediatric, child

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Osteochondritis dissecans (OCD) is a focal, idiopathic alteration of subchondral bone.[1] Konig[2] first described the condition in 1888. Although epidemiologic and incidence studies on OCD have been performed by Linden[3] and more recently by Kessler et al[4,5] and Weiss et al,[6] no studies have reported on the association between obesity and OCD in children. In particular, the association between weight class and pediatric OCD in a closed, self-contained population which limits losses to follow-up and provides more accurate, comprehensive incidence data is largely absent from the current literature.

The purpose of the present study was to evaluate the association between weight class and OCD of the knee, ankle, and elbow in an extremely large population-based cohort of children and adolescents in California.

METHODS

The methods for the identification of patients with OCD study were previously described by Kessler et al[4,5] for OCD of the knee and ankle. Briefly, after IRB approval was obtained for this cross-sectional study, we then assessed all patients aged 2 to 19 from the entire database of patients enrolled as members of a large, integrated Southern California health care system from January 2007 until August 2011. From this population, we retrospectively reviewed the electronic health records of inpatient, outpatient, and emergency department encounters for the first occurrence of an *International Classification of*

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On May 12, 2014, a subcommittee of the Kaiser Permanente Southern California (KPSC) Institutional Review Board (IRB) reviewed and approved this study.

The authors declare no conflicts of interest.

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Disease (ICD-9) code for OCD of the knee, ankle, and elbow for each cohort member during the years of study enrollment. The ICD-9 codes used to identify patients with OCD included: 732.5, 732.7, and 733.9. After identifying patients with these ICD-9 codes, we then used a natural language processing word search on all outpatient and inpatient records of these patients using the words "dessicans," "osteochondritis," "OCD," "osteochondral," and "dissecans" to identify patients with any of these terms in any inpatient or outpatient progress notes, operative reports, or radiology dictations. Inclusion criteria included isolated OCD lesions of the ankle, knee, and elbow in patients aged 2 to 19 at the time of diagnosis during the study period, and a recorded body mass index (BMI) within 1 year of the initial diagnosis of OCD. Exclusion criteria included osteochondral fractures and all other intra-articular cartilaginous, ligamentous, or bony injuries which were not clearly OCD. Radiographs and/or magnetic resonance imaging's and all charts were reviewed to ensure that a true OCD lesion existed.

We included age at study entry, sex, race, and ethnicity, and joint involvement as variables. Age at diagnosis for each patient was obtained from enrollment records and was categorized as 2 to 5, 6 to 11, or 12 to 19 years. We categorized race/ethnicity as non-Hispanic White, Hispanic, African American, Asian or Pacific Islander, and other (which included unknown or combined race/ethnicity).

In the assessment of BMI, we used all children enrolled in a large population-based cohort study, the Kaiser Permanente Southern California (KPSC) Children's Health Study 2007 to 2009, as our control group for assessing the association of BMI with risk of having OCD.[7] This was carried out because these 1,295,971 children in Kaiser Southern California already had their BMI data recorded and analyzed.[8,9] In keeping with this prior study, BMI was calculated as weight in kilograms divided by the square of the height in meters. The median BMI-for-age of all encounters in the year of study enrollment for each patient was used for analysis for all patients in the KPSC Children's Health Study. For patients identified to have OCD, the BMI closest to the date of diagnosis was used for analysis. Children were classified as underweight (BMI-for-age <5th percentile), normal weight (BMI-for-age ≥ 5th and <85th percentile), overweight (BMI-for-age ≥ 85th percentile or a BMI ≥ 25 kg/m^2), moderately obese (BMI-for-age ≥ 95th percentile or a BMI ≥ 30 kg/m^2), and extremely obese (BMI-for-age ≥ 1.2×95th percentile or a BMI ≥ 35 kg/m^2), based on a combination of sex-specific BMI-for-age growth charts developed by the CDC and WHO for overweight and obesity in adults.[7,10–12]

The associations between the 5 different weight classes and OCD of all joints, both combined and individually were assessed using multiple logistic regression models to estimate odds ratios (OR) and 95% confidence intervals. All models were adjusted for sex, race, age, and ethnicity. All analyses were conducted using SAS 9.2 (SAS Inc., Cary, NC). Kruskal Wallis testing was performed to compare the mean and median absolute and percent BMI between children with OCD and those without. The associations between OCD and BMI were assessed using multivariable logistic regression models to estimate OR and 95% confidence intervals. This was performed for each individual location of OCD and for all types of OCD combined. The multivariable logistic models controlled for age, sex, and ethnicity. An alpha level of 0.05 was used to determine statistical significance, that was used for all analyses.

RESULTS

From the original cohort of 317 patients with OCD, a total of 269 subjects fit the inclusion and exclusion criteria; 48 of 317 patients did not have a BMI recorded within 1 year of the diagnosis of OCD. There were 183 male individuals and 86 female individuals, with a male/female ratio of 2.1/1. As with the original cohort, the vast majority of patients were in the 12 to 19 year old group as opposed to the 6 to 11 year old group, with 217 and 52 patients, respectively. The majority of patients (157) had knee OCD, with the remainder having ankle (77) and elbow (32) OCD.

The breakdown by weight class for all patients with OCD was as follows: 30 patients (11.2%) extremely obese, 44 (16.4%) moderately obese, 50 (18.6%) overweight, 142 (52.8%) normal weight, and 3 (1.1%) underweight. This was significantly different from the Kaiser pediatric population as a whole ($P = 0.0069$), with only 6.8% and 13.4% of patients without OCD being extremely and moderately obese, respectively (Table 1). Mean and median absolute

TABLE 1. Study Patient Demographics for OCD of All Joints

	All Patients		Patients Without OCD		Patients With OCD		
Weight Class	No. Patients	Percent of Patients	No. Patients	Percent of Patients	No. Patients	Percent of Patients	P^a
All joints	924,660	100.0	924,391	99.97	269	0.03	0.0069
Extremely obese	62,495	6.8	62,465	6.8	30	11.2	
Moderately obese	123,587	13.4	123,543	13.4	44	16.4	
Overweight	161,331	17.4	161,281	17.4	50	18.6	
Normal weight	553,674	59.9	553,532	59.9	142	52.8	
Underweight	23,573	2.5	23,570	2.5	3	1.1	

OCD indicates osteochondritis dissecans.
[a]P-value obtained from χ^2 analysis.

TABLE 2. Absolute BMI and BMI Percent Differences Between Patients With and Without OCD

	Absolute BMI				BMI Percent			
	All Patients	Patients With OCD	Patients Without OCD	P^a	All Patients	Patients With OCD	Patients Without OCD	P^a
All joints				<0.0001				<0.0001
Mean (SD)	21.5 (5.68)	24.0 (5.89)	21.5 (5.68)		66.7% (28.95)	73.6% (26.00)	66.7% (28.95)	
Median	20.4	22.7	20.4		74.4%	81.7%	74.4%	
Q1, Q3	17.3, 24.3	19.9, 26.8	17.3, 24.3		45.2%, 92.9%	58.6%, 95.7%	45.2%, 92.9%	
Range	(5.6-97.1)	(11.6-49.0)	(5.6-97.1)		(0.0-100.0%)	(0.0-99.7%)	(0.0-100.0%)	
Ankle				<0.001				0.0018
Mean (SD)	21.7 (5.64)	25.7 (6.24)	21.7 (5.64)		68.4 (27.35)	77.2 (24.03)	68.4 (27.35)	
Median	20.6	24.3	20.6		75.6	85.3	75.6	
Q1, Q3	17.5, 24.4	21.3, 27.6	17.5, 24.4		47.9, 93.2	61.7, 96.2	47.9, 93.2	
Range	(10.0-97.1)	(16.5-42.8)	(10.0-97.1)		(5.0-100.0)	(8.5-99.7)	(5.0-100.0)	
Knee				<0.0001				0.0165
Mean (SD)	21.5 (5.68)	23.2 (5.67)	21.5 (5.68)		66.7 (28.95)	72.0 (27.53)	66.7 (28.95)	
Median	20.4	22.1	20.4		74.4	81.8	74.4	
Q1, Q3	17.3, 24.3	19.2, 25.8	17.3, 24.3		45.2, 92.9	56.1, 95.4	45.2, 92.9	
Range	(5.6-97.1)	(11.6-49.0)	(5.6-97.1)		(0.0-100.0)	(0.0-99.7)	(0.0-100.0)	
Elbow				0.0100				0.2611
Mean (SD)	21.6 (5.64)	24.0 (5.71)	21.6 (5.64)		68.6 (27.30)	74.0 (23.30)	68.6 (27.30)	
Median	20.5	22.0	20.5		76.0	78.7	76.0	
Q1, Q3	17.4, 24.4	20.0, 28.7	17.4, 24.4		48.3, 93.3	57.7, 98.2	48.3, 93.3	
Range	(10.0-97.1)	(16.9-38.0)	(10.0-97.1)		(5.0-100.0)	(19.6-99.5)	(5.0-100.0)	

BMI indicates body mass index; Q1, first interquartile; Q3, third interquartile; OCD, osteochondritis dissecans.
[a]Kruskal Wallis testing was used to determine *P*-values.

BMI for all OCD patients was significantly higher at 24.0 and 22.7, respectively, versus 21.5 and 20.4 for patients without OCD (Table 2, $P<0.0001$). The same held true for the mean and median percentile BMI, which was significantly higher at 73.6% and 81.7% for OCD patients, respectively, as opposed to 66.7% and 74.4% for non-OCD patients. In keeping with this, the mean and median BMI was also significantly greater for OCD in each individual joint versus non-OCD patients ($P<0.0001$ for ankle and knee and $P=0.01$ for OCD elbow). In terms of BMI percentile for the individual joints, the percentile BMI was significantly greater in patients with OCD of the ankle and of the knee ($P=0.0018$ and 0.017, respectively).

In the multivariate analysis, extremely obese and moderately obese patients were found to have an increased OR of all OCD, with an 86% and 60% increased risk, respectively, compared with normal weight patients. In addition, extremely obese patients had an increased OR of OCD of the elbow and ankle individually, with 3.1 and 3.0 times the risk of elbow and ankle OCD, respectively (Table 3, $P=0.02$ and 0.01, respectively). The increased OR of ankle OCD in moderately obese patients did not reach statistical significance with $P=0.1$. Although extremely obese patients did not have a significantly increased OR of knee OCD, moderately obese patients had a 1.8 times increased risk of knee OCD ($P=0.009$). Of note, there was not a significantly different risk for any type of OCD seen in either overweight or underweight groups of children.

DISCUSSION

Very little literature exists on the association between patient BMI and overall risk for OCD. Hankemeier et al[13] found obesity to have a significant negative clinical impact on the results of bone marrow stimulation in OCD of the ankle. In an assessment of operative treatment of OCD of the ankle in children with an average age of 14.3 years, Kramer found that elevated BMI was a significant negative predictor of the Foot and Ankle Outcome score (FAOS).[14] Ollat et al,[15] in a review of a mixed group of patients with focal cartilaginous defects of the

TABLE 3. Logistic Regression and Odds Ratios for Risk of OCD by Body Mass Index

	Odds Ratio	Confidence Interval	P^a
All Joints			
Extremely obese vs. normal weight	1.8585	(1.25-2.77)	0.0022
Moderately obese vs. normal weight	1.5961	(1.13-2.25)	0.0072
Overweight vs. normal weight	1.3055	(0.94-1.80)	0.1062
Underweight vs. normal	0.4780	(0.15-1.50)	0.2060
Ankle			
Extremely obese vs. normal weight	2.9762	(1.54-5.74)	0.0011
Moderately obese vs. normal weight	1.7464	(0.91-3.37)	0.0957
Overweight vs. normal weight	1.4055	(0.77-2.56)	0.2661
Knee			
Extremely obese vs. normal weight	1.2540	(0.68-2.31)	0.4665
Moderately obese vs. normal weight	1.7685	(1.15-2.71)	0.0088
Overweight vs. normal weight	1.4128	(0.93-2.14)	0.1021
Underweight vs. normal	0.8157	(0.26-2.58)	0.7291
Elbow			
Extremely obese vs. normal weight	3.1248	(1.23-7.92)	0.0163
Moderately obese vs. normal weight	0.8842	(0.26-3.00)	0.8437
Overweight vs. normal weight	0.8593	(0.29-2.53)	0.7832

No elbow or ankle OCD lesions were found in the underweight group and thus comparisons could not be made to the underweight group in these joints.
OCD indicates osteochondritis dissecans.
[a]*P*-value indicates significance of the effect of predicting OCD.

knee—61 of whom had OCD—found that obesity had no significant impact on clinical results. Lastly, Woelfle et al[16,17] found no significant impact on the outcome of OATS treatment for OCD of the talus due to obesity. We are unaware of any previous studies specifically assessing the risk of OCD of any joint based on BMI.

In the present study, the risk was consistent among extremely obese patients for OCD of the ankle, elbow, and all joints combined. Although the etiology of OCD is not well defined, mechanical factors that alter or increase stress on the joints such as malalignment,[18] repetitive microtrauma,[19] and abnormal meniscus anatomy[20,21] have been associated with lesion development. Therefore, association between obesity and OCD of the weight bearing joints seems fairly intuitive. The relationship between obesity and OCD of the elbow is less clear, however, as increased weight would not be expected to significantly increase stresses on the elbow joint. It is also unclear why the OR for knee OCD was not significantly higher in extremely obese patients, yet was significantly higher in moderately obese patients. Differences in activity level could have an effect on the risk of OCD. Perhaps extremely obese patients are relatively inactive and alter their risk of knee OCD by decreasing their exposure to high impact activities. However, as this study was retrospective, it was not possible to assess differences in activity level between the OCD and non-OCD groups.

Our study is not without limitations. As it was a retrospective study design, it is possible some OCD patients may have been missed, and patients with asymptomatic OCD lesions are less likely to have had imaging studies and are thus less likely to have been diagnosed. However, the use of a comprehensive electronic medical record, all-encompassing ICD-9 codes, and text search algorithms of the records minimized the chance of missed diagnoses among these patients. In addition, 48 patients from the original cohort were excluded due to the fact they did not have a recorded BMI within 1 year of the date of OCD diagnosis. Lastly, we were unable to assess activity level of the patient groups. Although the results of our study come from a single health system, the Kaiser Permanente health system includes a large, diverse population which is likely a reasonable representation of the larger US population or at least that of much of the western and southwestern United States given the similar ethnic makeup of these areas.

To our knowledge, this study presents the first and only true assessment of the association between BMI and the risk of OCD in pediatric patients in a closed, self-contained population. This study demonstrates a dramatically increased overall risk of OCD in moderately and extremely obese patients. Extremely obese patients also showed an increased risk of ankle and elbow OCD. Although extremely obese patients did not show a significantly increased risk of knee OCD, moderately obese patients had almost double the risk for knee OCD. The absolute mean and median BMI was significantly greater in OCD patients whether they were separated by individual joints or combined into a single group. Given these findings, providers should have a heightened suspicion for OCD in obese patients. Future research is needed to further investigate the relationship between OCD and patient BMI, and to compare long-term treatment outcomes between different weight and activity level patient groups.

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