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What are the Demographics and Epidemiology of Legg-Calvé-Perthes Disease in a Large Southern California Integrated Health System?

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Abstract

Background Although many authors have reported the incidence of Legg-Calvé-Perthes disease (LCPD), there have been few incidence studies in the United States on large, self-contained populations such as those within an integrated health system. Understanding the epidemiology and demographics of LCPD in this setting may help clinicians identify patients at the greatest risk and aid in diagnosis and subsequent treatment.

Questions/purposes In this study we sought (1) to determine the incidence and demographics of LCPD in a large cohort of children and adolescents in a Southern California integrated healthcare system, and (2) to identify any demographic or clinical factors (such as age, sex, race/ethnicity, or BMI) that are independently associated with LCPD.

Methods A retrospective chart analysis was done on patients diagnosed with LCPD within our integrated healthcare system in patients aged 2 to 12 years over a 3-year period between 2010-2012. There were nearly 800,000 children in this cohort. Patient demographics were recorded; the incidence of LCPD was determined for the entire group and by sex, age, and race/ethnicity. Odds ratios for an association with LCPD based on age, sex, BMI and race/ethnicity were determined using logistic regression models.

Results The LCPD incidence per 100,000 for all children was 2.84, with the highest incidence in 2- to 5-year-old children (3.05; 95% CI, 1.51-4.59) and the lowest in 9- to 12-year-old children (1.06; 95% CI, 0.21-1.91). Incidence varied markedly among ethnicities, with the highest incidence in whites (5.69; 95% CI, 3.13-8.24) and the lowest in Asians (0.78; 95% CI, 0.00-2.32). Data analysis revealed a 3.13-times increased odds ratio (OR) of LCPD in 2- to 5-year-old patients versus 9- to 12-year-olds ($p = 0.011$), and boys had a 12.44 times greater OR of LCPD than girls ($p < 0.001$). Data analysis showed an increased OR for LCPD (3.41; 95% CI, 1.28-9.09) in patients with extreme obesity (BMI-for-age $\geq 1.2 \times$ 95th percentile or a BMI ≥ 35 kg/m^2) compared with patients with a normal BMI.

Conclusions Our study of a large integrated healthcare system in Southern California revealed an increased

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Each author certifies that his institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. This study was performed at Kaiser Permanente Southern California, Los Angeles, CA, USA.

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association of male sex and young age (2 to 5 years old) with LCPD. The overall incidence was lower overall than previously reported, although the incidence seen in white patients was similar to that in prior studies. The finding that patients with extreme obesity may have an increased association with LCPD merits further study. These findings may increase providers' awareness of the risk of the disease in younger patients and in extremely obese patients, and it also merits further future investigation as to whether there is a cause or effect relationship between extreme obesity and LCPD.

Level of Evidence Level IV, prognostic study.

Introduction

Legg-Calvé-Perthes disease (LCPD) is an idiopathic avascular necrosis of the femoral head that was initially independently described by Legg [18], Calvé [5] and Perthes [29] in 1910. Although many authors have investigated LCPD incidence and associated risk factors [3, 6, 10, 30], the etiology of LCPD remains unclear and the incidence has been found to vary widely based on sex, race, and geographic region of the study population. Other risk factors such as socioeconomic status [13, 23, 27], urban versus rural environment [27, 34], and maternal smoking status [2, 13] have all been implicated in LCPD development. In addition, it appears from recent studies that LCPD incidence may be decreasing over time [23].

Although there are many studies on LCPD, few have been performed in the United States on large, diverse, self-contained populations, such as those within an integrated health system. Incidence data on black and Hispanic populations is particularly sparse compared with Asian and white populations. There is also little information on the relationship of body mass index (BMI) and LCPD [24].

The purposes of the present study were (1) to determine the incidence and demographics of LCPD in a large cohort of children and adolescents in a Southern California integrated healthcare system, and (2) to identify any demographic or clinical factors (such as age, sex, race/ethnicity, or BMI) that are independently associated with LCPD.

Patients and Methods

Institutional review board approval was obtained for this cross-sectional study. We assessed all patients aged 2 to 12 years from the entire database of patients enrolled as members of the Kaiser Permanente Health System from January 2010 until the end of 2012. Our institution is an integrated health care system that encompasses Bakersfield at its northern end to the Mexican border in southern San Diego county. It includes 12 hospitals and hundreds of medical office buildings and is staffed by 10 fellowship-trained pediatric orthopaedic surgeons serving a large, racially, ethnically, and socioeconomically diverse population of about 4.2 million patients, including nearly 800,000 children. Because Kaiser is a not-for-profit organization, it accepts many Medi-Cal patients, who make up approximately 10% of all members. As such, this population represents both private-paying and underinsured patients. From this population, we retrospectively surveyed the electronic health records of inpatient, outpatient, and emergency department encounters for the first occurrence of an ICD-9 code for LCPD for each cohort member during the years of study enrollment.

The ICD-9 codes used to identify patients with LCPD were 732.1 (juvenile osteochondrosis of the hip and pelvis) and 732.9 (unspecified osteochondropathy). The inclusion criterion was LCPD in patients aged 2 to 12 years at the time of diagnosis during the study period. We chose to limit inclusion at the age of 12 because an LCPD diagnosis beyond this age is rare as per multiple authors [8, 12, 21, 25]. Exclusion criteria included osteochondral hip fractures, femoral head or neck fractures, slipped capital femoral epiphysis, all other intraarticular cartilaginous bony injuries which were not clearly LCPD, or LCPD diagnosed before 2010 to avoid confusing incidence with prevalence. In addition, to ensure this was truly an incidence study, we excluded any patients with LCPD diagnosed before 2010, either inside or outside of Kaiser. Patients at all radiographic stages of disease were included if this was truly their first radiograph documenting LCPD. After identifying patients with the initial 128 ICD-9 codes, all inpatient and outpatient progress notes, emergency room, operative reports, and radiographs (x-rays and MRIs) were reviewed and diagnosis was confirmed by a single author (JK). Of note, x-rays existed for both hips at the time of diagnosis to confirm whether patients had bilateral disease or any other hip pathology. Patients were required to be enrolled in Kaiser for at least the entire calendar year of diagnosis to be included. Ultimately, 86 patients were found to have other hip pathology than Perthes, leaving 42 patients with 51 total diagnoses of LCPD who fit the inclusion and exclusion criteria.

Age at diagnosis, sex, race and ethnicity, BMI, and side involved were all included as variables in this study. Age of each patient was obtained from the electronic medical record (EMR) and patients were grouped by age at diagnosis: 2 to 5 years, 6 to 8 years, and over 8 years, as multiple authors have demonstrated differences in outcomes based on these age groups [4, 11, 19, 20, 31]. We categorized race/ethnicity as nonHispanic white, Hispanic, non-Hispanic black, Asian or Pacific Islander, and other (which included unknown or combined race/ethnicity). A prior validation study compared race and ethnicity from health plan administrative records and birth certificates of

325,810 children [33] and found that the positive predictive value for Hispanic ethnicity was 95.6%, for white ethnicity it was 89.3%, for black ethnicity it was 86.6%, for Asian/Pacific Islander ethnicity the proportion was 73.8%, and for other it was 1.2% [14-16].

In the BMI assessment, we used all children from our health system as our control group for assessing the association of BMI with LCPD risk, as more than 95% of all patients in this age group had their BMI recorded in the EMR from 2010 to 2012. Body mass index was calculated as weight in kilograms divided by the square of the height in meters, and the BMI recorded for the patients with LCPD was the BMI closest to the date of diagnosis that was no more or less than 3 months from the diagnosis date. The median BMI-for-age of all encounters in the years of study enrollment for each pediatric patient without LCPD was used to analyze all patients. Children were classified into one of five weight categories: 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 [1, 7, 14, 17].

We calculated the frequency of LCPD by age group, weight class, sex, and ethnicity. Incidence was calculated for LCPD in all patients, along with incidence by age group, sex, and race/ethnicity. Univariate logistic regression analysis was used to determine risk factors for LCPD and covariates that were significant at the 0.05 alpha level in the univariate logistic regression. We used multivariable logistic regression analysis to estimate odds ratios (OR) and 95% confidence intervals (CI) of having LCPD while controlling for potential confounders. The outcome models included race (nonHispanic white, Hispanic, black, Asian or Pacific Islander, other/unknown), age, BMI, and sex. Possible interactions between age, sex, BMI, and ethnicity were examined using likelihood ratio tests. An alpha level of 0.05 was used to determine statistical significance. We used the SAS® Enterprise Guide version 4.2 (SAS Institute Inc, Cary, NC, USA) for all analyses.

Results

Incidence

The incidence of LCPD for all children 2 to 12 years of age was 2.84 per 100,000. During the study period, 42 patients (51 hips) with LCPD were identified. Of the nine patients with bilateral disease, the second side was diagnosed within 18 months or less of the first hip being diagnosed with LCPD. There were 28 patients in the 2- to 5-year-old group, eight in the 6- to 8-year-old group, and the remaining six were in the 9- to 12-year-old group (p = 0.016; Table 1). Mean age at diagnosis was 4.7 years (± 2.49 years), and median age was 4.0 years. Thirty-nine of 42 patients were boys (p < 0.001).

In all, 22 of 42 patients (52%) had left-side involvement; 11 patients (26%) had right-side involvement, and nine (21%) had bilateral involvement.

Factors Associated with a Diagnosis of LCPD

We found an OR of 3.13 for LCPD in 2- to 5-year-old patients versus 9- to 12-year-olds (95% CI, 1.30–7.69; p = 0.011), and an OR of 1.86 of LCPD in 2- to 5-year-old children compared with the 6- to 8-year-olds (95% CI, 0.85–4.00; p = 0.122, Table 2) after controlling for the confounders of sex, BMI, and ethnicity. This was consistent with the incidence by age, which revealed an incidence of 3.05 per 100,000 (95% CI, 1.51–4.59) in the 2- to 5-year-old group, 2.06 per 100,000 (95% CI: 0.63–3.48) in the 6- to 8-year-old age group, and 1.06 per 100,000 (95% CI: 0.21–1.91) in 9- to 12-year-old children (Table 3).

Boys had an OR of 12.4 for LCPD compared with girls (95% CI, 3.84–40.26; p < 0.001; Table 2) when controlling for other confounders. The incidence for boys was 5.13 per 100,000 and 0.42 per 100,000 for girls (Table 3).

The incidence varied markedly among ethnicities, with an incidence in white patients of 5.69 per 100,000 (95% CI, 3.13–8.24) and an incidence of 0.78 per 100,000 (95% CI, 0.00–2.32) in Asian patients. Black patients had an incidence of 1.59 per 100,000 (95% CI, 0.00–3.80), the incidence was 2.32 per 100,000 (95% CI, 1.22–3.42) for Hispanic patients, and patients in the other/unknown category had an incidence of 1.61 per 100,000 (95% CI, 0.00–3.84; Table 3).

In the BMI analysis, patients with extreme obesity had an increased risk of LCPD (Table 2), with an OR of 3.41 for LCPD compared with patients of normal weight (95 % CI, 1.28–9.09; p = 0.014). We found no difference in OR for LCPD in patients with moderate obesity compared with patients of normal weight (OR, 2.01; p = 0.096) nor in patients who were overweight or underweight compared with patients of normal weight (Table 2). At the time of diagnosis, 13 of 42 patients with LCPD were obese, and nearly half (19 of 42) were either overweight or obese (Table 1). Median BMI percentile for LCPD patients was higher at 83% versus 69% for patients without LCPD (p = 0.020).

Discussion

LCPD is relatively rare, and although other studies have reported its incidence, there are few US or North American

Table 1. Cohort demographics including weight class, ethnicity, sex, and age

Comparison	Patients without LCPD (n = 788,067)	Patients with LCPD (n = 42)	Total patients (n = 788,109)	p value†
Weight class*				0.056
Extremely obese	28,455 (4.7%)	5 (11.9%)	28,460 (4.7%)	
Moderately obese	77,296 (12.6%)	8 (19%)	77,304 (12.6%)	
Overweight	95,095 (15.6%)	6 (14.3%)	95,101 (15.6%)	
Normal	388,120 (63.5%)	20 (47.6%)	388, 140 (63.5%)	
Underweight	22,293 (3.6%)	3 (7.1%)	22,296 (3.6%)	
Ethnicity				0.012
Asian	62,178 (7.9%)	1 (2.4%)	62,179 (7.9%)	
Black	66,068 (8.4%)	2 (4.8%)	66,070 (8.4%)	
Hispanic	403,780 (51.2%)	19 (45.2%)	403,799 (51.2%)	
Unknown	69,708 (8.8%)	1 (2.4%)	69,709 (8.8%)	
White	186,333 (23.6%)	19 (45.2%)	186,352 (23.6%)	
Sex				< 0.0001
Boys	402,680 (51.1%)	39 (92.9%)	402,719 (51.1%)	
Girls	385,387 (48.9%)	3 (7.1%)	385,390 (48.9%)	
Age				0.016
2-5 years	357,961 (45.4%)	28 (66.7%)	357,989 (45.4%)	
6-8 years	190,005 (24.1%)	8 (19.0%)	190,013 (24.1%)	
9-12 years	240,101 (30.5%)	6 (14.3%)	240,107 (30.5%)	

*Weight classes: extremely obese, BMI for age $\geq 1.2 \times$ 95th percentile or a BMI $\geq$ 35 kg/m^2; moderately obese, BMI for age $\geq$ 95th percentile or a BMI $\geq$ 30 kg/m^2; overweight, BMI-for-age $\geq$ 85th percentile or a BMI $\geq$ 25 kg/m^2; normal, BMI for age $\geq$ 5th and < 85th percentile; underweight, BMI for age < 5th percentile; 611,259 of the 788,067 patients without LCPD had a BMI recorded within 3 months of their age at analysis were included as controls in the analysis by weight class.
†p values were calculated using a chi-square test.

incidence studies [9, 22] and to our knowledge, none have analyzed a broad geographic region and a large cohort from an integrated healthcare system. The incidence of LCPD has been found to vary between different ethnic and geographic populations [28], thus the incidence of United States and North American populations represents an important knowledge gap. In addition, information on LCPD in Hispanic and black populations and its association with BMI is particularly sparse. Demographic and etiological knowledge is important for clinicians in making a differential diagnosis of any disease, and identifying associated risk factors is key for the design of future studies attempting to establish disease causality. We sought to determine the incidence and demographics of LCPD in an ethnically diverse population and identify factors that might be associated with increased disease risk.

Our study has some limitations. First, as a retrospective study, it is possible to have missed some patients with LCPD and therefore underestimated the incidence of this condition in this population. We also included all possible ICD9 codes for LCPD, some of which could have been miscoded. Given the usual long-standing limp and frequency of symptoms associated with LCPD, we believe it is unlikely for there to have been missed asymptomatic patients. Another downside of the present study is that we were unable to control for household income and other socioeconomic factors in our analysis of LCPD risk. Given that a lower number of Kaiser Southern California patients (approximately 10%) have Medi-Cal as compared with the estimated 30% of the entire Southern California population that is covered by Medi-Cal, it is possible, and even likely, that the captured population was of a somewhat higher socioeconomic status than the entire Southern California population. Race and ethnicity in this electronic medical record is all self-reported, which may potentially be different than the true race for some patients. Lastly, maternal smoking exposure may also be a risk factor for LCPD [2, 13], and we were unable to assess this given the incomplete information present in our database.

The present study is one of the few LCPD incidence studies performed in the United States or North America [9, 22], and was performed using a large, integrated health system covering a racially and geographically diverse population, in contrast to previous studies. Our LCPD incidence of 2.8 per 100,000 in the 2- to 12-year-old age group was lower than most other studies. However, we did

Table 2. Odds ratios for LCPD between weight class, ethnicity, sex, and age groups

Comparison	Odds ratio	95% confidence interval	p value
Weight			
Extremely obese versus normal	3.41	1.28-9.09	0.014
Moderately obese versus normal	2.01	0.89-4.56	0.096
Overweight versus normal	1.22	0.49-3.05	0.664
Underweight versus normal	2.61	0.78-8.79	0.121
Ethnicity			
White versus Asian	6.34	0.85-50.0	0.072
White versus Black	3.37	0.79-14.29	0.102
White versus Hispanic	2.17	1.15-4.17	0.017
Other versus White	7.11	0.95-50.0	0.056
Black versus Hispanic	0.64	0.15-2.76	0.552
Black versus Asian	1.88	0.17-20.76	0.606
Asian versus Hispanic	0.34	0.05-2.55	0.295
Sex			
Boys versus girls	12.44	3.84-40.26	< 0.001
Age			
2-5 years versus 6-8 years	1.86	0.85-4.00	0.122
2-5 years versus 9-12 years	3.13	1.30-7.69	0.011
9-12 years versus 6-8 years	0.59	0.21-1.71	0.334

The p value indicates the significance of the odds ratio for LCPD.

find an annual incidence of 5.7 per 100,000 in whites, which was not dramatically different from that of the most frequently assessed populations in England. Of note, these English populations from several decades ago were predominantly white. In an epidemiologic review, Barker et al. [3] found the highest recorded incidence of LCPD in Liverpool, England at 15.6 per 100,000 children. According to a study by Hall et al., [10] the annual estimated incidence was 30 per 100,000 in boys and 5 per 100,000 in girls from 1948-1968 [3, 10]. Elsewhere in England, as well as in the United States, Canada, and South Africa rates have been reported to range from 5.1 to 10.8 per 100,000 [3]. In 1966, Molloy and MacMahon [22] estimated the incidence in Massachusetts at 5.7 per 100,000. In their in-depth meta-analysis of the epidemiology of LCPD, Perry et al. [28] pointed out the incredibly diverse and varying incidence rates of LCPD based on both region and ethnicity. In addition to noting that whites consistently have the highest incidence of disease, they concluded that, irrespective of race, with each 10° increase in latitude there is a 1.44 times increased risk of disease. This may play an important role in the lower overall incidence seen in the present study as compared with some of the landmark studies in the UK, since the latitude of our Southern California population varied from 35° to 32.5° north compared with a latitude of at least 51° in the UK.

Table 3. Incidence of LCPD by ethnicity, sex, and age (cases per 100,00 children)

Comparison	Incidence	95% confidence interval
Ethnicity		
Asian	0.78	0.00-2.32
Black	1.59	0.00-3.80
Hispanic	2.32	1.22-3.42
Unknown	1.61	0.00-3.84
White	5.69	3.13-8.24
Sex		
Boys	5.13	3.50-6.76
Girls	0.42	0.00-0.91
Age		
2-5 years	3.05	1.51-4.59
6-8 years	2.06	0.63-3.48
9-12 years	1.06	0.21-1.91

The present study demonstrates a more frequent onset of LCPD in young children, with an incidence of 3.1 per 100,000 in the younger age group, 2.1 per 100,000 in the middle age group, and 1.1 per 100,000 in the oldest age group. Median age of onset was 4.0 years. Molloy and MacMahon [22] found that annual incidence rates in Massachusetts peaked between 4 and 8 years, while Chacko et al. [6] found an older age of onset with the mean age at onset of symptoms of 9.89 years for boys and 8.71

years for girls [6]. Other more recent studies have found similar mean ages of onset of 5.7 years [23], 6 years [32], and 5.8 years [34], which are all somewhat older than in our study. We are unsure why the population in our study had a lower age of onset; however, it could reflect ethnic differences because our cohort was predominately Hispanic, while none of the referenced studies reported on Hispanic populations.

Our study clearly confirms the male propensity for LCPD, with an OR of 12.4 for disease in boys and an incidence of 5.1 per 100,000 in boys compared with 0.42 per 100,000 in girls. Male predominance of LCPD is well established, with a male-to-female ratio ranging from 2:1 up to 6:1 [3, 6, 22]. A Liverpool study found the incidence was 30 per 100,000 in boys and 5 per 100,000 in girls from 1948-1968 [3, 10]. Hall et al. [10] estimated an incidence by sex of 10.2 per 100,000 in males and 2.2 in females in Yorkshire, England and also found "geographical differences in incidence which could not be explained by urban-rural or social class differences." Our study, which included an ethnically and geographically diverse population confirms sex as an independent risk factor for LCPD.

We found that nonHispanic whites had an OR from 2.2 up to 7.1 for disease versus any other ethnicity and also had an increased risk for LCPD (OR = 2.17; 95% CI, 1.15–4.17) when compared with Hispanics. Purry [30] estimated the incidence at 10.8 per 100,000 in whites, versus 0.45 per 100,000 in blacks and 1.7 per 100,000 in mixed race children in the Eastern Cape region of South Africa in 1982. The systematic review by Perry et al. [28] found that whites were at greater risk for LCPD compared with all other races; however, that study did not include any predominately Hispanic populations. Thus, our study provides the first information, to our knowledge, on the incidence of disease in Hispanic children, and of their odds of disease relative to other races. The minority (23.6%) of whites compared with 51.2% Hispanics in our study population may also explain the lower LCPD incidence.

In this integrated healthcare system cohort study, extreme obesity was also strongly associated with LCPD, and patients with LCPD had a higher BMI than the large control group. In addition, 30.9% of the LCPD patients in this cohort were obese and nearly half (45.2%) were either overweight or obese compared with the control group, of which 17.3% of patients were obese. This correlated quite closely with the findings from Neal et al. [24], in which 32% were obese and 48% were either obese or overweight in their study of 148 LCPD patients. Of note, the control population's 17.3% obesity prevalence mirrored closely that of the US pediatric population as estimated by Ogden et al. [26], who found a 16.9% prevalence of obesity in 2011-2012. Although it is impossible to determine causality due to the retrospective nature of our study, we believe that it is most likely the case that obesity is a risk factor for developing LCPD. Because BMI data was from within 3 months of LCPD diagnosis, it seems less likely that development of obesity would be a result of decreased activity secondary to hip pain; however, this possibility cannot be ruled out. Nevertheless, it appears that, like many other orthopaedic diseases, extreme obesity is associated with increased LCPD incidence [1].

The study population was larger than many prior incidence and demographic studies of LCPD and reflects a more modern assessment of the demographics of the disease in an ethnically and racially diverse Southern California population. The Kaiser Southern California population is fairly representative of the ethnic diversity of California as a whole, with a predominance of Hispanics (51%) in the control group and a minority of whites (24%), African Americans (8%) and Asians (8%). Compared with the US Census Bureau statistics for California in 2017–which found a distribution of 37% nonHispanic whites, 39% Hispanics, 6.5% African Americans, and 15% Asians–the Kaiser population had a slightly greater proportion of Hispanics, and a lower proportion of whites and Asians. Both the present study population and California's population as a whole have a much lower percentage of whites and much higher percentage of Hispanics than that of the United States, where the US Census Bureau has estimated 18.1% of the population are Hispanic and 60.7% are nonHispanic whites. The present study demonstrated a lower disease incidence than many prior studies [3, 10, 22], along with the greater propensity of LCPD in boys and younger children. In addition, we showed that, consistent with the findings of Perry et al. [28] nonHispanic whites have by far the highest disease risk, with an incidence similar to numbers quoted in the classic studies on LCPD demographics. Finally, this study demonstrated a greater association with the disease in very obese patients. The epidemiology and demographics of LCPD must be understood not only based on age and sex, but also on race and ethnicity. Understanding the epidemiology and demographics of LCPD in this setting may help clinicians better identify patients at the greatest risk and aid in diagnosis and subsequent treatment. We believe that orthopaedic surgeons, but perhaps especially pediatricians and primary care physicians, will benefit from having increased knowledge and awareness of the patients at greatest risk for LCPD including boys, whites and possibly patients with extreme obesity.

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