Effect of seasonal variation on the peak presentation of slipped capital femoral epiphysis. A comparison of children in Johannesburg, South Africa and London, UK

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Variation exists in the peak presentation of slipped capital femoral epiphysis (SCFE). The objective of this study was to compare two cohorts of children (South Africa and the UK) and explore similarities and differences regarding demographic and epidemiological features, incidence and seasonal variation in peak presentation. Patients presenting with SCFE at one of two hospitals were included in the study. A retrospective cohort was collected from hospital records. The following factors were recorded: duration of symptoms, chronicity, stability, seasonality, severity and prophylactic pinning. A total of 137 patients were included in the study – 70 patients (80 hips) from South Africa and 67 patients (73 hips) from the UK. Both sites recorded more than 50% incidence of a chronic slip. There was higher delay to presentation in the UK compared with South Africa (90 vs 60 days, *P*=0.0262). The UK population were more skeletally mature (32.8% open triradiate cartilage) compared with the South Africa population (64.9% open triradiate cartilage). In both populations, the most common season of symptom onset was summer. In the UK, the most common season of symptom presentation was in autumn compared with summer in South Africa. This study found significant differences in the two countries, including a more skeletally mature population in the UK. Both cohorts showed seasonal variation in peak incidence, but there was more seasonal variation in peak incidence in the UK – in the summer for onset of symptoms and autumn months for time of presentation. *J Pediatr Orthop B* 29:268–274

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Introduction

Slipped capital femoral epiphysis (SCFE) is a rare hip disorder affecting young adolescents, potentially resulting in long-term morbidity related to both the natural history and the surgical management of the hip [1]. Many demographic and epidemiological factors affecting SCFE have been studied both in high and low-to-middle income countries. These factors include age, gender, ethnicity, duration of symptoms, bilateral involvement, stability, severity, BMI, vitamin D levels and seasonality.

Seasonal variation in the peak presentation of SCFE was first shown at a global level by Loder in 1996 [2] and since then, a number of other studies have found similar findings [2–5]. Essentially, the variation in peak presentation increases as the latitude increases over 40° north of the equator but not south of the equator [2].

The focus of the current study was to determine the seasonal variation of SCFE presentation in two cohorts of patients on either side of the equator. The aim was to take a snapshot of each cohort – one in Johannesburg, South Africa at a latitude of 26.2° south of the equator (with 3124.4 hours of annual sunshine) and the other in London, UK, at a latitude of 51.5° north of the equator (with 1633 hours of annual sunshine) [6]. The study compared the two cohorts of children and explored similarities and differences regarding demographic and epidemiological features, incidence and seasonal variation in peak presentation.

Methods

Study setting

Chris Hani Baragwanath Academic Hospital (CHBAH) is the third largest hospital in the world situated at latitude 26.2° south of the equator and 27.9° east of the Greenwich meridian in Soweto, South Africa. During the study period, CHBAH was the only public hospital in Soweto, which admitted patients with SCFE, with an estimated population of 1.5 million people accessing the hospital [7]. Access to private healthcare in Soweto is low, with almost 100% of hospital admissions occurring at CHBAH. All SCFE cases were referred to CHBAH.

The Royal London Hospital (RLH) is part of the Barts Health Trust and is one of the largest hospitals in the UK and part of the largest NHS Trust. It is situated at latitude

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51.5° north of the equator and 0.1° west of the Greenwich meridian in London, UK. All cases of SCFE in the local region are admitted to this hospital and it is a tertiary referral centre for large parts of London and the South East of England. In 2016, it provided services for around 2.5 million people [8].

Study population

Patients presenting with SCFE to CHBAH and RLH between 2011 and 2017 were enrolled retrospectively in this study. Potential study participants were identified through ward admission books, operative records in theatre, and the paediatric out-patient department records at CHBAH and through electronic hospital records at RLH. Children included required a confirmed date of birth, admission date and radiographs which were accessible for viewing.

Medical records for study participants were collected from the hospital records in both hospitals. Demographic and clinical information ascertained included admission date, age, date of birth, gender, ethnicity, duration of symptoms before diagnosis (calculated by subtracting admission date from date at onset of symptoms), stability (ability to bear weight), season of presentation, severity of slip, prophylactic pinning and whether the triradiate cartilage was open or closed at presentation.

Measurements

Duration of symptoms, chronicity and stability

The duration of symptoms was recorded from the initial onset of pain until presentation at hospital. Symptoms less than three weeks were classified as acute and symptoms more than three weeks as chronic. A stable SCFE was defined as a patient who was able to bear weight either fully or partially, with or without crutches and unstable if the patient was not able to bear any weight on the affected leg.

Seasonality

Seasons were classified using the UK Meteorological Office [9]: In the southern hemisphere, summer is defined as from 1 December until 28 February; autumn is from 1 March until 31 May; winter is from 1 June until 31 August and spring is from 1 September until 30 November. In the northern hemisphere, winter is from 1 December until 28 February; spring is from 1 March until 31 May; summer is from 1 June until 31 August and autumn is from 1 September until 30 November. Both the season of initial onset of symptoms and season of presentation were recorded.

Severity of slipped capital femoral epiphysis

The Southwick angle was used to categorize slip severity [6,7]. The femoral head shaft angle was utilized from either the frog leg lateral plain radiograph or computed tomography (CT) scan. The picture archiving and communication system was used to measure the angles. The slips were then categorized into mild (<30°), moderate (30°–50°) or severe (>50°). In cases of bilateral SCFE, the Southwick angle was measured using the difference from the 'normal' value of 145°, as defined by Southwick.

Triradiate cartilage and prophylactic pinning

The same radiographs and CT scans were utilized to determine whether the triradiate cartilage was open or closed. Medical records and postoperative radiographs were used to assess whether prophylactic pinning had been performed. At CHBAH, the method using the Oxford bone score (specifically an open triradiate cartilage) was used to determine the need for contralateral prophylactic fixation while at RLH, the posterior slope angle was used to decide whether a prophylactic pin would be inserted [10,11].

Statistical methods

Yearly incidence was calculated per 100 000 population as the number of events divided by the mid-year population estimates and multiplied by 100 000. Overall incidence per 100 000 population was calculated as the total number of events divided by the median population estimate between 2011 and 2017 and then multiplied by 100 000. Exact confidence intervals for Poisson counts were used to give 95% confidence interval (CI) for the estimated incidence.

Demographic and clinical features were described using means and SDs for normally distributed variables and medians and interquartile range (IQR) for non-normal variables. Percentages were reported for categorical variables.

To explore the seasonality of disease, we used a goodness-of-fit test for discrete multivariate data, where the null hypothesis was that the probability of a case occurring in any season is 25%. Fisher's exact test was used to determine the association between season of onset of symptoms and clinical and demographic variables.

Results

A total of 70 patients were included from CHBAH (80 hips) and 67 patients from RLH (73 hips) giving a total population of 137 patients (153 hips) (Table 1). The mean age of children presenting with SCFE was 12.4 and 11.9 years in South Africa and UK, respectively (Table 1). Forty-seven percent of the patients from South Africa were males, while 60% of patients from the UK were males. In South Africa the majority of patients were black (91 and 44%, respectively; Table 1).

The majority of children from both cohorts presented with stable SCFE – in the South African cohort 67% were stable and in the UK cohort 76% were stable at presentation. Chronic SCFE was seen in the majority of patients

Table 1 Demographic and clinical characteristics of slipped capital femoral epiphysis patients

Variable	CHBAH	NHS BARTS	P value
Mean age in years (SD)	12.41 (1.7)	11.90 (1.84)	0.0901
Male (%)	33 (47%)	40 (59.7%)	0.1714
Race			
Asian	1 (1.47%)	11 (17.74%)	
Black	62 (91.18%)	27 (43.55%)	
Mixed race	4 (5.88%)	6 (9.68%)	
White	1 (1.47%)	18 (29.03%)	<0.001
Median duration of symptoms in days (IQR)	60 (7–140)	90 (42-180)	0.0262
Chronicity (%)			
Acute	25 (35.71%)	12 (20.34%)	
Acute on chronic	3 (4.29%)	16 (27.12%)	
Chronic	42 (60%)	31 (52.54%)	0.0006
Side (%)			
Bilateral	10 (14.29%)	6 (8.96%)	
Left	40 (57.14%)	35 (52.24%)	
Right	20 (28.57%)	26 (38.81%)	0.3779
Stable (%)	47 (67.14%)	45 (76.27%)	0.3290
Severity			
Mild	37 (66.07%)	24 (35.82%)	
Moderate	10 (17.86%)	28 (41.79%)	
Severe	9 (16.07%)	15 (22.39%)	0.0024
Open triradiate cartilage	37 (64.91%)	22 (32.84%)	0.0005
Prophylactic pinning	43 (61.43%)	32 (47.76%)	0.1243

CHBAH, Chris Hani Baragwanath Academic Hospital; IQR, interquartile range.

(60% from the southern hemisphere and 53% from the northern hemisphere) although a higher percentage from the UK had acute on chronic symptoms (27 vs 3%; P value = 0.0006). In the current study, delay to presentation was higher in the UK cohort (median 90 days) compared with the South African cohort (median 60 days). This difference was statistically significant ($P = 0.0262$). There was a statistically significant majority of patients who presented with chronic slips in both cohorts (the UK cohort 53% and South African cohort 60%; P value = 0.0006). Patients from South Africa mostly presented with mild SCFE (66%) and patients from the UK presented mostly with moderate (42%) SCFE. The UK population were more skeletally mature (32.8% had an open triradiate cartilage) compared with the South African cohort (64.9% had an open triradiate cartilage).

Bilateral involvement was seen in 9% of the UK children compared with 14% of the South African children (Table 1). The majority from both cohorts were stable slips – 76% in the UK cohort compared with 67% in the South African cohort (Table 1). High rates of prophylactic pinning were seen both in the UK cohort (47.8%) and the South African cohort (61.4%).

The yearly incidence at CHBAH was relatively stable between 1.5 and 2 cases per 100 000 population with the exception of 2012, where there were 3.6 cases per 100 000 population. No population denominators were available to estimate incidence at RLH.

Seasonality of slipped capital femoral epiphysis presentation

Figures 1 and 2 show that at CHBAH, there was both a peak in onset of symptoms and a peak in presentation in the summer months – the latter was statistically significant ($P = 0.0218$). Figure 1 also shows that at RLH, although there were more patients who had symptoms which started in the summer compared with the other months, this was not found to be statistically significant ($P = 0.4293$). Figure 2 shows that autumn was the most common season of presentation at RLH, but that this was not significant ($P = 0.1504$).

Seasonality and time to presentation

There was no significant relationship between season and the demographic variables listed in Table 1 except for chronicity at CHBAH. The majority of chronic patients had symptoms that started in winter and spring at CHBAH but at RLH, the majority of chronic patients had symptoms which started in summer. Acute patients at CHBAH were more likely to present in summer, whereas there was no significant relationship between seasonality and chronicity at RLH (Fig. 3a and b).

Discussion

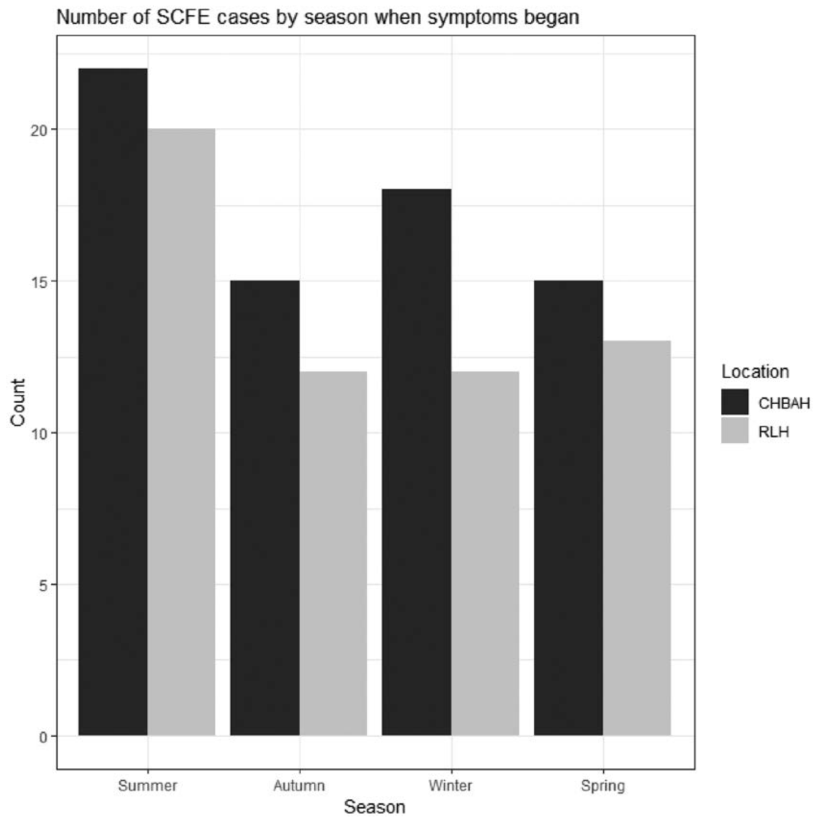
The populations studied here come from two different geographical locations. The average annual sunlight in Johannesburg is 3124.4 hours which is almost double that of London at 1633 hours [6]. Johannesburg lies at 26.2° south of the equator and London lies at 51.5° north of the equator. These differences make a significant impact on the peak presentation of SCFE in each cohort of patients and the authors postulated that it was these solar differences that would warrant a snapshot comparison of these two cohorts.

Most girls present with SCFE between 11 and 12 years of age compared with boys who present between 12 and 13 years of age [12]. Recent studies have shown that the age at presentation has been decreasing compared with older studies. This may reflect earlier maturation of children today [13]. The current study found that ages were not reduced compared with traditional literature – the South African cohort presented later (12.41 years) than the UK cohort (11.9 years), but this was not statistically significant. It is also interesting that the UK population, although slightly younger, were more skeletally mature than the South African cohort.

Data from the UK were consistent with other studies reporting that males were slightly more often affected by SCFE than females [12,14]. However, this was not found to be the case in South Africa, where there were slightly more females presenting with SCFE.

The average duration of symptoms before diagnosis can be up to five months [14,15]. Perry *et al.* [15] showed that diagnostic delay occurred in up to 75% of their cohort within the UK who had multiple contacts before diagnosis and a third of them presented with knee pain on initial presentation. The delays experienced in referral pathways and difficulty in primary care workers making

Fig. 1



Number of SCFE cases by season when symptoms appeared. SCFE, slipped capital femoral epiphysis.

the diagnosis of SCFE are possible explanations for the lengthy time between onset of symptoms and presentation seen in our study.

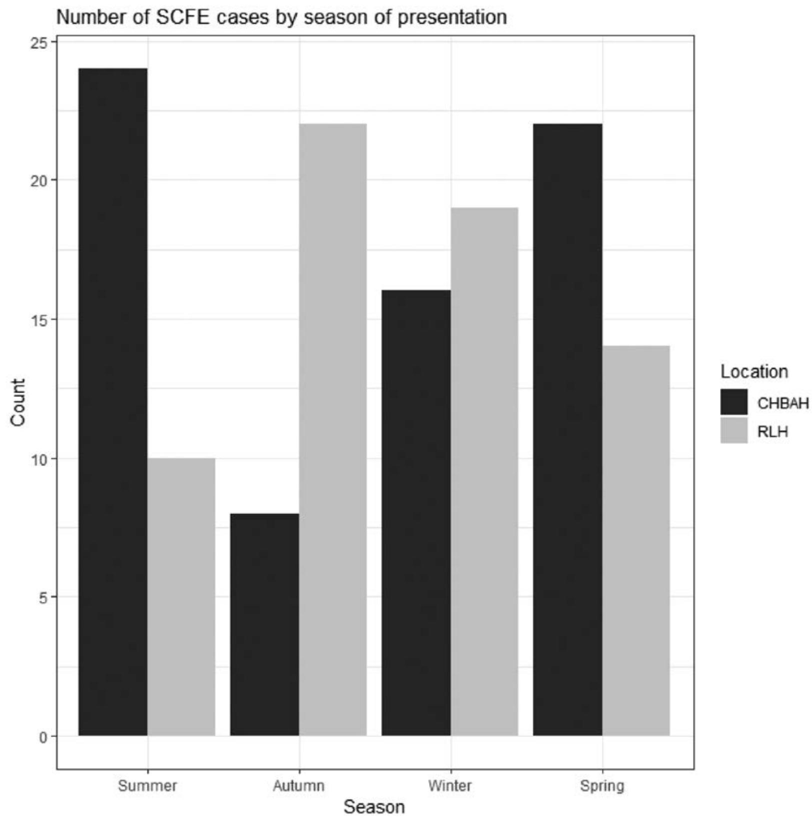
Studies have shown that up to 50% of patients present with bilateral involvement [14]. This can increase to up to 66% at skeletal maturity [16,17]. African children have been recorded as having bilateral involvement in 34% of cases [14]. This in contrast to a study by Herngren *et al.* [12] which found that only 7% of Swedish children had bilateral involvement on presentation. These figures are similar to those found in the population from RLH but lower than those from CHBAH. The gold standard of treating SCFE is with in situ fixation [12–14,18].

This was supported by a survey of the UK surgeons which found that 96% of respondents used in situ fixation [18]. The use of prophylactic pinning is more controversial and in the UK is used in about 27% of cases [18]. A delay to surgical management of SCFE can correlate with an increase in the slip angle and result in more complicated surgery being required [19]. The low rate of bilateral involvement in both cohorts (9% in the UK cohort and 14% in the South African cohort) resulted in a relatively high rate of prophylactic pinning (47.8% in the UK cohort and 61.4% in the South African cohort).

The incidence of SCFE varies from region to region around the world, but it does seem to be rising – this rise has been postulated to correlate with rising levels of obesity in the world although this association has only been described in first world countries [1,12,14–17,20–24]. In the United States, the overall incidence of SCFE has been estimated at around 10.8 cases/100 000 with a 3.9 times greater incidence in black children and 2.5 times greater incidence in Hispanic children compared with white children [24]. In the UK, Perry *et al.* [17] reported a rate of 4.8/100 000 children under the age of 16 years. In contrast, the highest incidence described worldwide was in New Zealand where rates of up to 80/100 000 have been described in local populations [20]. Although Loder [2] included patients from South Africa, no other studies have specifically looked at the incidence of SCFE in South Africa. The incidence of 13.8/100 000 for the South African group in the current study is more than double that of the UK incidence shown by Perry *et al.* [15] and slightly higher than that of studies from the United States [24].

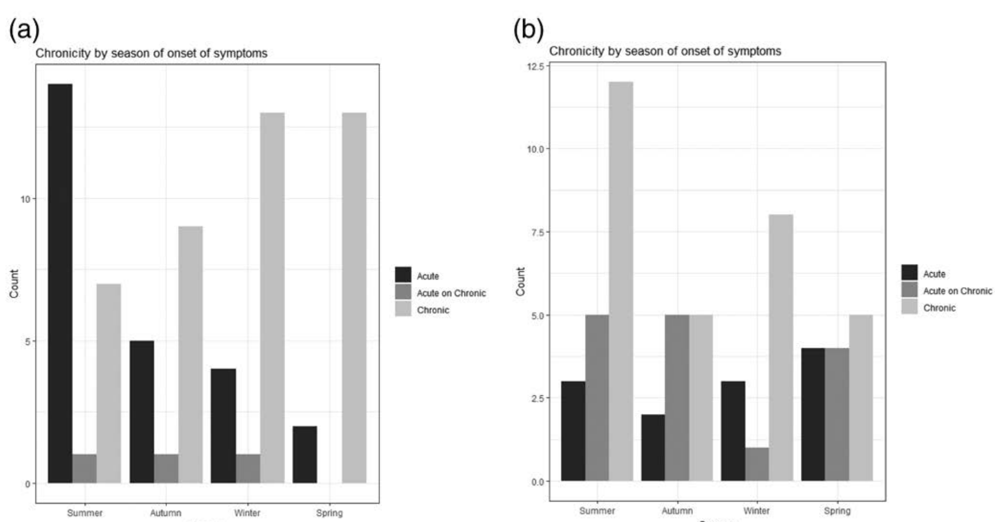
Until now, the association of seasons with the peak presentation of SCFE has been mentioned only briefly in the literature. Most studies have shown that seasonality is a significant factor for countries that are more than 40°

Fig. 2



Number of SCFE cases by season of presentation. SCFE, slipped capital femoral epiphysis.

Fig. 3



(a) Chronicity by season of onset of symptoms at CHBAH. (b) Chronicity by season of onset of symptoms at RLH. CHBAH, Chris Hani Baragwanath Academic Hospital; RLH, The Royal London Hospital.

north of the equator. This significance decreases between 20° and 40° north of the equator and has not been shown to be significant in the southern hemisphere [2–5].

In the article by Loder *et al.*, 1630 children were studied with SCFE from around the world. This study included all six continents and 33 orthopaedic centres. The month of onset showed significant variation in North America and Europe but not in Africa, Asia, Australia, New Zealand or South America. In this article, there were 69 children from Africa (44 from South Africa and 25 from Algeria) and 188 children from Europe (36 from Ireland and 152 from Slovenia). The main finding of this article was that seasonal variation in peak presentation was more common in regions further north than 40° latitude. The current study includes a larger population from South Africa (70 patients) and the UK (67 patients).

In 2002, Maffulli and Douglas [3] studied 1103 patients with SCFE in Scotland and reported that they had a peak in SCFE admissions in the autumn. They hypothesized that the season of spring corresponded with a peak in growth which combined with an autumn peak in weight resulted in a higher number of SCFE admissions. The current study corroborates these findings in that the peak season for admissions for the UK cohort was also in the autumn, whereas in South Africa, it was in the summer [3].

In 2015, Farrier *et al.* [4] performed a meta-analysis on the seasonality of the peak incidence of SCFE and found a strong correlation between the fluctuation in SCFE presentation and hydroxy-vitamin D3. They hypothesized that increasing levels of hydroxy-vitamin D3 accelerate growth, and therefore, increase the risk of a physeal slip. This has been termed catch up growth. The current study supports this hypothesis in both cohorts – the peak incidence of symptom onset was in summer but this remained summer in South Africa for time of presentation and shifted to autumn in the UK cohort. This may reflect the increased sunlight the children in the UK cohort were getting from the onset of summer and into the autumn months when daylight hours are significantly longer than in the winter months. The higher number of sunlight hours in South Africa over the winter months may also have caused higher levels of Vitamin D across all seasons compared with the UK population.

In a recent paper by Loder and Schneble [5], sunlight exposure correlated with seasonal variability and for regions further north than 35° latitude, August was the month for peak admissions. They also showed that in regions with less than 2500 hours of annual sunlight, there was seasonal variation. This was borne out in the current study where in the UK cohort with 1633 hours of annual sunlight, there was seasonal variation in both the season of onset of symptoms and admissions.

Limitations

Although previous studies have shown that vitamin D deficiency and seasonality are associated with each other [4,5], the current study did not measure vitamin D levels – this has been noted as the first limitation of this study.

Many studies have shown that there is a very high rate of obesity associated with SCFE. Herngren *et al.* [12] found that the majority of their patients with SCFE were overweight or obese. Perry *et al.* [15,17] showed that the mean BMI in a population of patients with SCFE was two SDs above normal and that a strong causal association was confirmed between obesity and SCFE in a UK population. The current study did not record the BMI and this is the second main limitation of the current study.

Conclusion

This study has compared two cohorts from either side of the equator and found significant differences including a more skeletally mature population in the UK. Both cohorts showed seasonal variation in peak incidence but there was more seasonal variation in peak incidence in the UK – in the summer for onset of symptoms and autumn months for time of admission.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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