Pediatric Neurology 52 (2015) 424–427

Contents lists available at ScienceDirect

Pediatric Neurology

journal homepage: www.elsevier.com/locate/pnu

Original Article

Diurnal and Seasonal Occurrence of Febrile Seizures

Kirsi Mikkonen MD *, **Matti Uhari MD, Tytti Pokka MSc, Heikki Rantala MD**

Department of Pediatrics, University of Oulu, Oulu, Finland

ABSTRACT

BACKGROUND: Febrile seizures are the most common seizures in children, but their pathogenesis remains unknown. Some studies have suggested an association between the light-dependent secretion of melatonin and the occurrence of febrile seizures. The diurnal and seasonal occurrence of febrile seizures could clarify the role daylight plays in febrile seizures. **METHODS:** In Finland, summer days are long and bright and winter days are short and dark. We evaluated the diurnal and seasonal occurrence of the first febrile seizures in 461 children and adjusted them according to the epidemiology of the febrile episodes in a population-based study of 1522 children. **RESULTS:** The first febrile seizure most often occurred in the evening, peaking between 6 and 10 PM (31%), and least often at night, in the early morning hours between 2 and 6 AM (8%) ($P < 0.001$). This diurnal pattern repeated itself in different seasons according to variance in daylight duration. Febrile seizures occurred irregularly throughout the year, most frequently in winter, concurrently with the febrile episodes, and least frequently in summer; this seasonal variation in the occurrence of febrile seizures disappeared however when adjusted for the number of febrile events. **CONCLUSIONS:** We found clear diurnal and seasonal variations in the occurrence of febrile seizures, even though they did not follow the amount of daylight. Our findings do not support the hypothesis that the diurnal and seasonal variation of daylight explains the occurrence of febrile seizures. Moreover, febrile events associated strongly with the occurrence of febrile seizures.

Keywords: febrile seizure, seasonal variation, diurnal variation, daylight, melatonin, children

Pediatr Neurol 2015; 52: 424-427

Introduction

Febrile seizures are the most common seizures in children, usually occurring between 6 months and 6 years of age and affecting about 2%-5% of all children.[1,2] Their recurrence is common, with about 20%-30% of patients experiencing more than one febrile seizure.[2] The pathogenesis of febrile seizures remains unknown.

Changes in exposure to light synchronize the suprachiasmatic nucleus in the anterior hypothalamus of the brain, which coordinates many circadian rhythms, such as sleep, behavior, metabolism, and hormone secretion.[3] Melatonin (N-acetyl-5-methoxytryptamine) is secreted mostly at night and in the dark, and exposure to light reduces its secretion.[4] Melatonin seems to possess some anticonvulsant effects[5-8]; some studies suggest an association between melatonin and the occurrence of febrile seizures[9-11] also as an explanation to the epidemiology of febrile seizures.[10,11] Many types of epileptic seizure occur according to a specific circadian rhythm.[12]

Because of its location in the far north (i.e., north of 60° N), Finland has very long, bright summer days and very long, dark winter nights. In the city of Oulu in northern Finland, the length of the day as measured from sunrise to sunset on the winter solstice in December is only about 3.5 hours; on the summer solstice in June it is more than 22 hours.[13] Moreover, the duration of daylight in southern Finland differs from that in Oulu in northern Finland only by about 2-3 hours during the darkest or the brightest periods of the year.[13] On the winter solstice in Oulu, the sun rises only 2° above the horizon, but on the summer solstice, it rises more than 48° above the horizon. We evaluated the diurnal and seasonal variations of the first febrile seizures and adjusted them to both the number of febrile episodes and the body temperature measured in connection with the febrile seizures.

Article History:
Received October 25, 2014; Accepted in final form January 5, 2015

* Communications should be addressed to: Dr. Mikkonen; Children's Castle, P.O. Box 280, FIN-00029 HUS, Finland.
E-mail address: kirsi.h.mikkonen@hus.fi

0887-8994/$ – see front matter © 2015 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.pediatrneurol.2015.01.001

We hypothesized that if daylight or melatonin is a part of the pathogenesis of febrile seizures, the occurrence of febrile seizures should show diurnal and seasonal variations and associate with the duration of daylight, even when adjusted for the number of febrile episodes or body temperature.

Patients and Methods

We evaluated diurnal and seasonal variations in the occurrence of febrile seizures among 461 consecutive patients who had experienced their first febrile seizure. The patients were recruited between November 1986 and September 1990[14-16] and between January 1997 and December 2003,[17] mostly from the Department of Pediatrics and Adolescence, Oulu University Hospital,[14-17] but also from four other hospitals (Satakunta, Central Finland, Päijät-Häme, and South Karelian),[17] each of which is the only children's hospital in the region. The patients participated in our earlier risk factor and prevention trials of febrile seizures,[14-17] which reported their detailed follow-up schedules.[14-17] The study was carried out in accordance with the Declaration of Helsinki, the ethics committee of the University of Oulu Medical Faculty approved the protocols of the study, and the parents provided written, informed consent. We had a unique opportunity to compare the seasonal occurrence of febrile seizures with the seasonal variation of febrile episodes in children of the same age and from the same region. The population-based data on febrile episodes came from a study of 1522 children in 20 randomly selected day care centers in the region of Oulu, Finland, conducted between March 1991 and May 1992 (Table).[18] In that study, the occurrence of infections and symptoms of the child were recorded in daily symptom diaries completed by the parents. The parents recorded their child's body temperature in the diaries any time the child fell ill.[18]

Of the patients, 29% had experienced complex febrile seizure and 25% had parents or siblings who had experienced febrile seizure (Table). A febrile seizure was considered complex when it was either focal or prolonged (>15 minutes) or if more than one seizure had occurred within a 24-hour period. The hospital admission date was recorded for all 461 children included in the analysis of seasonal variation. For 223 of these patients, who were also included in the analysis of diurnal variation, hospital admission time was recorded, and the time the febrile seizure occurred was asked of the parents upon their arrival at the hospital. Patients' body temperature was measured upon their arrival at the hospital. The control group of day care children (N = 1522) experienced a total of 2478 febrile episodes (body temperature higher than 38°C) during the 15-month study period.

Statistics

Day was classified into six 4-hour time periods according to the duration of daylight; the period from 10 AM to 2 PM was considered the brightest. Similarly, the year was classified into three 4-month periods according to the duration of daylight. The period from May to August was considered the brightest, and the period from November to February the darkest; March and April, together with September and October, formed one 4-month period during which the amount of daylight was between the length of the other two periods. We calculated the ratios of febrile episodes to febrile seizures to investigate whether the monthly occurrence of febrile seizures associated with the number of febrile episodes. The chi-squared goodness-of-fit test served to detect whether the observed diurnal proportions of febrile seizures depart from the even distribution. The Walter and Elwood test served to detect seasonal variation in the occurrence of febrile seizures.[19] All data were analyzed with IBM SPSS Statistics for Windows, version 21.0, and Stata/IC for Windows, version 11.2.

TABLE.
Demographic Characteristics of Patients With Their First FS and Controls With Febrile Episodes

Characteristic	Patients	Controls
	n = 461	n = 1522
Mean age, year (SD; range)	1.7 (0.8; 0.3-5.6)	3.6 (1.8; 0.3-7.6)
Female (%)	183 (40)	758 (50)
Simple/complex FS	327/134	-
Family history of FS, yes/no*	110/334	-
Family history of epilepsy, yes/no†	10/393	-

Abbreviations:
FS = Febrile seizure
SD = Standard deviation
No data were available for *17 and †58 patients.

Results

The occurrence of the first febrile seizure did not follow an even distribution ($P < 0.001$), and the number of febrile seizures increased during the day and in the evening, peaking between 6 and 10 PM (31%); the lowest number occurred at night in the early morning hours between 2 and 6 AM (8%) ($P < 0.001$) (Fig 1). The occurrence of febrile seizures followed the same pattern and peak hours during the 24-hour period, even when examined separately during the three 4-month periods based on the amount of daylight (Fig 2).

The number of febrile seizures was the highest in winter, coinciding with a peak in febrile episodes, and the lowest during summer, coinciding with infrequent febrile episodes (Fig 3). When adjusted for the number of febrile episodes, we found no seasonal variation in the occurrence of febrile seizures ($P = 0.29$). The maximum temperature of the fever in patients with febrile seizures (mean 39.7°C, range 37.6-42.0°C) was similar throughout the year.

Discussion

In our study, children experienced their first febrile seizure most often in the evening and less frequently at

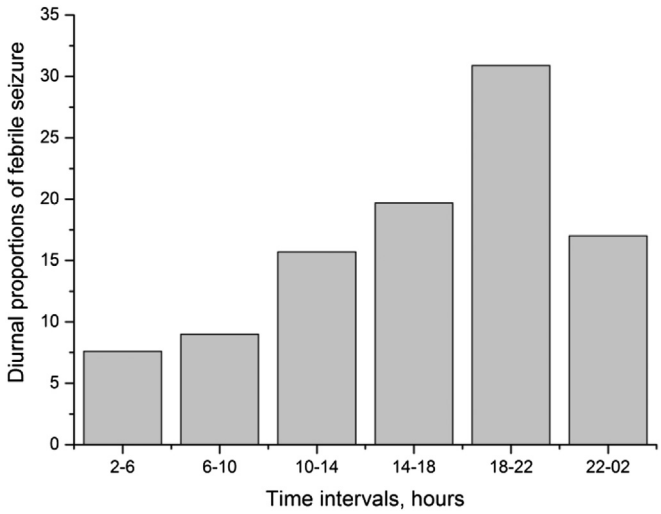

FIGURE 1.
Diurnal variation in the occurrence of the first febrile seizure in children. Chi-squared test for even distribution $P < 0.001$.