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The effects of weather on pediatric seizure: A single-center retrospective study (2005–2015)

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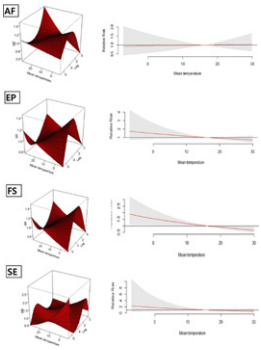
HIGHLIGHTS

- Among pediatric patient visiting our emergency department (108,628), there were 3,484(3.2%) visits for any type of seizure.
- Half of total pediatric seizure patients were febrile seizure (53.5%) and the proportion for status epilepticus were the lowest (5.9%).
- Of the many weather factors, only mean temperature was affected by lagged effects.
- Only febrile seizure among four types was affected by the mean temperature.

GRAPHICAL ABSTRACT

Three-dimensional plot of relative risks along mean temperature and lags for ED visits according to four seizure types with reference as median[a].
Abbreviations: RR = relative risk; AF = afebrile seizure; EP = epilepsy; FS = febrile seizure; SE = status epilepticus. [a]Median of mean temperature was 15.9 °C. Red line means relative risk. Gray zone means 95% confidence interval of relative risk. If a 95% confidence interval contains zero, then the relative risk means not significance under significance level of 0.05.



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ABSTRACT

Background: Several studies have reported an association between seizure and the weather. However, reports are conflicting. Thus, we investigated whether emergency department visits due to seizure are affected by weather.
Methods: We retrospectively analyzed 108,628 emergency department visits to Samsung Changwon Hospital by pediatric patients from January 2005 to December 2015. Among them, there were 3484 (3.2%) visits for any type of seizure. Seizures were categorized as febrile seizure, afebrile seizure, epilepsy, or status epilepticus. We used a distributed lag non-linear model with quasi-Poisson distribution to investigate the association between weather and pediatric seizure.
Results: During this 11-year study period, over the half of total pediatric seizure patients were febrile seizure (53.5%) and the proportion for status epilepticus were the lowest (5.9%). Mean of mean temperature and diurnal temperature range were 14.7 °C and 8.3 °C. Mean humidity was 62.1%, mean of atmospheric pressure was 1015.5 hPa and mean of sunshine was 6.3 Hr. When considering the overall 0–15 days lagged effect of weather, only mean temperature was significantly associated with emergency department visits. At lower temperatures, the number of emergency department visits increases and decreases at higher temperatures. All 4 types of

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seizure also showed similar patterns. In particular, only visits of febrile seizure were significantly associated with mean temperature.
Conclusion: We investigated the association weather and pediatric seizure by considering 0–15 day lags. In particular, low mean temperature increase the emergency department visits for pediatric seizure and high mean temperature decrease the pediatric seizure. In addition, only febrile seizure of 4 seizure types was affected by mean average temperature.

1. Introduction

Many people believe that seizures can be induced by certain weather conditions, and several studies have reported an association between seizure and weather. For example, the seizure frequency of epileptic patients has been shown to be influenced by changes in atmospheric pressure (AP) and season or daily temperature (Altimiras-Roset et al., 2014; Doherty et al., 2007; Ruegg et al., 2008). High concentrations of ambient sulfur dioxide (SO_2) are also associated with increased probability of emergency department (ED) visit for seizure associated with ischemic cerebral accidents or transient ischemia (Szyszkowicz et al., 2012). Unstable weather conditions have been found to induce an increase in the frequency of seizures in almost half of epileptic patients in spring, autumn, and winter, but only in 7% in summer (Motta et al., 2011). Frequency of febrile seizure was found to be the highest in the winter and lowest in the summer and approximately five times greater in the evening than in the early morning (Millichap and Millichap, 2015; Ogihara et al., 2010). In addition, alterations in AP within the artificial environment of a high-pressure hyperbaric chamber have been shown to be associated with seizure (Millichap and Millichap, 2015). However, in other studies, the frequency of seizures showed no statistical correlation with AP, rainfall, degree of humidity, mean temperature, or sunshine (Altimiras-Roset et al., 2014; Millichap and Millichap, 2015; Ogihara et al., 2010). In this study, we investigated whether ED visits due to seizure were affected by weather over an 11-year study period (2005–2015). Additionally, we analyzed the effects of weather factors on ED visits according to season and seizure type.

2. Materials and methods

2.1. Data collection and study setting

The study population included pediatric patients under 19 years of age from Changwon who were admitted to the ED of Samsung Changwon Hospital from January 1st 2005 to December 31st 2015, a total period of 4017 days, with the main diagnosis of seizure (International Classification of Diseases, 10th Revision [ICD-10] codes: G40–G41, R56). Our institution is the only medical school hospital in Changwon and had the only pediatric neurologist in Changwon city during the study period. Changwon is in Gyeongsangnam-do province of South Korea, which is located on the southeast coast of South Korea (36° 13′ N, 128° 40′ E). According to the Korean Statistical Information Service (KOSIS) website (http://kosis.kr), the numbers of citizens in Changwon in 2015 was 1,066,036. Its climate is influenced by several factors, including the nearby sea. Changwon therefore has an oceanic climate with an average annual temperature of 14.7 °C and is influenced by the monsoon, with slightly damp and hot summers and dry, less snowy and cool to mild winters. There are many industrial complexes in Changwon, which can introduce air pollutants. Before data were collected, approval for this retrospective study was obtained from the Institutional Review Board of Samsung Changwon Hospital, Sungkyunkwan University School of Medicine. Daily weather data in Changwon for the same period were retrieved from the Korea Metrological Administration (KMA) website (www.kma.go.kr). Daily mean temperature (°C), maximum temperature (°C), minimum temperature (°C), humidity (%), atmospheric pressure (hPa), cloud cover (tenths), wind speed (m/s), and sunshine (Hr) were gathered and analyzed. Diurnal temperature range (DTR) was defined as the difference between the daily maximum and minimum temperature, and atmospheric pressure (AP) was defined as the average of the daily APs. We collected and analyzed daily average ambient concentrations of air pollutants from the Korean Ministry of Environment (MOE) website (www.airkorea.or.kr). The 24-h average concentrations of particulate matter with a median aerodynamic diameter less than or equal to 10 μm (PM_{10}, $\mu g/m^3$) and maximum 1-h average concentrations of ozone (O_3, ppm), nitrogen dioxide (NO_2, ppm), carbon monoxide (CO, ppm), and sulfur dioxide (SO_2, ppm) were used as air pollution variables.

We collected the following demographic data from retrospective review of medical records: patient age and sex, arrival date, previous ED visits according to seizure, duration of seizure, frequency of seizure, presence or absence of fever, experience of previous seizure, times of arrival and departure from ED, residential address, results of treatment, and final diagnosis. Seizure was categorized as febrile seizure (FS), afebrile seizure (AF), seizure of known epilepsy (EP), or status epilepticus (SE). We defined FS as a seizure occurring in febrile children aged from 1 to 60 months who did not have a central nervous system infection, metabolic disturbance, or history of previous seizure without fever according to the definition of the International League Against Epilepsy (Epilepsia, 1993). We also categorized seizures occurring in individuals older than 60 months with generalized epilepsy with febrile seizure (GEFS) as FS. AF referred to convulsion without fever, for example, generalized convulsion with mild gastroenteritis and a single seizure without fever. EP was defined as two or more seizure episodes without fever but not AF. SE was defined as a continuous seizure lasting >30 min or a series of epileptic seizures longer than 30 min during which function was not regained between ictal events (Epilepsia, 1993). Additionally, we investigated the relationship between weather and seizure according to season. Season definitions were as follows: spring (from March to May), summer (from June to August), autumn (from September to November), and winter (from December to February).

2.2. Statistical analysis

To find out the lagged effects of various weather variables, a distributed lag non-linear model (DLNM) was used to simultaneously investigate the non-linear and delayed effects of weather on ED visits (Gasparrini, 2011; Gasparrini et al., 2010). We used lags up to 15 days to capture the overall effects. We controlled for seasonality and long-term trends using a natural cubic spline with 7 degree of freedom per year for time. We used mean temperature to assess temperature effects in this study. Air pollutants such as PM_{10}, O_3, NO_2, CO, and SO_2 were controlled for as potential confounding variables. The model used for the analysis was as follows with quasi-Poisson distribution for daily counts of ED visits for pediatric seizures:

$$\mathrm{LogE}[Y_t] = \alpha + DTR_{t,l} + T_{t,l} + H_{t,l} + S_{t,l} + AP_{t,l} + P_s + ns(Time, 7^*11) + offset(population_i)$$

where t is the day of observation; Y_t is the number of visits due to seizure on day t; α is the intercept; $DTR_{t,l}$, $T_{t,l}$, $H_{t,l}$, $S_{t,l}$, $AP_{t,l}$ are matrix elements obtained by applying the DLNM to DTR, mean temperature,