Temperature and holiday impacts on early childhood fracture

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ABSTRACT

Objectives: Hospitalizations and surgeries of extremity fractures in childhood after emergency admissions have been increasing steadily. One-third of under seventeen-year-old children have at least one fracture; most of them are on the extremity. The relationship between weather conditions and children's fractures is well known. This study aims to reveal the effects of weather conditions and holidays on pre-school and primary school children's (2-12-year-old) extremity fractures.

Methods: All children between 2 and 12-year-old and extremity fractures during the decade of 1 January 2017 and 31 December 2018 were included in the present study. The population was studied in two groups: pre-school and primary school. Monthly meteorological information, the number of holidays, and fracture numbers were compared.

Results: There was a significant relationship between all extremity fractures and monthly average temperature, warm days, and hot days. A negative correlation was detected between cold days and all upper-lower extremity fractures. In both groups, there was a positive correlation between hot days and upper extremity and total fracture numbers. There was no correlation between fracture numbers and monthly holiday numbers in both groups.

Conclusions: We researched the effects of monthly average temperature and the number of holidays on pre-school and primary school children. Results show that there is a close relationship between temperature and fracture numbers. Not only on warm days, as stated in the literature, but also on hot days fracture incidence is increasing. We found no correlation in our study between the number of holidays and the number of fractures.

Keywords: temperature, child, bone fracture, holidays.

Hospitalizations and surgeries of extremity fractures in childhood after emergency admissions are increasing steadily. One of every four children in the United States has urgent medical care, and the rate of fractures in childhood has been reported to be from 12.0 to 36.1/1000 and more than 50,000 in the UK per year [1, 2]. One-third of under seventeen-year-old children have at least one fracture and most of them are on the extremity [3-5]. These common fractures affect the daily life and socio-economic conditions of the parent. The relationship between weather condi-

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tions and the most common childhood fractures as the supracondylar humerus, femur shaft, and forearm fracture is shown [3, 6, 7].

Children older than two years are generally very active than adults depend on the weather temperatures, and usually, this activity results in an injury. Seasonal variations of child fracture numbers have been demonstrated in many studies using different parameters. Several studies described the relationship between children's fractures and temperature. Daily, weekly, temperatures, monthly minimum and maximum temperatures are used for his descriptions and almost all of these studies have similar results [6, 8-11]. As a general belief, fractures are thought to be associated with holidays, as they peak during the summer months, but results do not support this hypothesis [4].

This study aimed to compare pre-school and school-age children who had fractures to determine how weather affects this cohort. Our hypothesis is that extremity fractures in childhood change upon weather temperature, whether the school is open or not.

METHODS

Ethics committee approval was received from the ethics committee of our hospital (Approval number: 2011-KAEK-25 2020/08-13) to conduct this study. Trauma admissions data were collected from the hospital software system between 1st January 2017 and 31st December 2018 (24 months). International classification of diseases (ICD) codes looked up obtaining all children who had extremity fractures (S42.0-9, S52.0-9, S62.0-8, S72.0-9, S820-9, S92.0-9). Inclusion criteria were (1) children who had fractures between two and 12 years old, (2) performed the surgery or cast, (3) personal trauma lead to fractures that were included in this study. Fractures by influence external forces (e.g., traffic accident and assault), hand phalangeal fractures were excluded because of sharing with the plastic surgery department. Besides the clinical, demographic variables, this study investigated the comparison of the holiday and workdays how they affect the fractures for both groups.

Demographic and clinical data were obtained from patients' records that included gender, age, diagnosis and fractures area (Table 1). We divided the population into two age groups regarding pre-school and school-age. The first group was between two and six years old (pre-school age), and the second group was between 7-12 years old (school age).

Bursa is the fourth biggest city in Turkey and approximately two and a half million people live in the city. The weather temperature of Bursa was obtained from the Turkish State Meteorological Service official website and Bursa international meteorology station (station number: 17116). According to weather daily average temperature (DAT), the cold days (CD), warm days (WD) and hot days (HD) were defined under 15 degrees, between 15 and 22 degrees and over 22 degrees, respectively. We used two years of temperature data to avoid the negative effects of unexpected temperature changes.

We used these formulas for monthly average temperature (C^{o}) below:

Monthly average temperature (MAT)(C^{o})= (Total of daily average temperatures) ÷ (Total days in the same month)

Daily average temperature (DAT)(C^{0})= (Total of all temperature measurements(C^{0}))÷(Number of measurements)

In these two years, we determined cold, warm and hot days for each month. We used heating degree days and cooling degree days on the official meteorology website for cut-off values. (https://mgm.gov.tr/veridegerlendirme/gun-derece.aspx?g=merkez&m=16-00&y=2019&a=04).

Not only weather conditions but also the number of holidays was calculated monthly. All weekend and bank holidays (e.g., national, religious and weather conditions) were counted in the month they belong to.

Statistical analysis

SPSS 25.0 for Windows was used for statistical analysis. Descriptive statistics; numbers and percentages for categorical data and mean, standard deviation, minimum and maximum values for numerical data were used. Comparisons of numerical variables in two independent groups were made using the Mann-Whitney U test when the normal distribution condition could not be achieved. After the normality test, Kolmogorov-Smirnov and Shapiro-Wilk test, relationships between numerical variables were analyzed using Pearson Correlation Analysis when parametric test condition was met and Spearman Correlation Analysis when parametric test condition was not met. Statistical alpha significance level was accepted as $p < 0.05$.

RESULTS

Five thousand eight hundred twenty-eight fractures were detected in all children. Two thousand one hundred ninety-four fractures were excluded due to that those younger than 2-year-old or older than 12-year-old and who had phalangeal fractures. The fractures by external influences (e.g., road accidents and child abuse) were excluded because they were not related to temperature and repetitive entries were also excluded (Figure 1). In all fractures (2-12-year-old), there was a significant relationship with all (upper-lower) extremity fractures and MAT, WD, HD. A negative correlation was detected between CD and all upper-lower extremity fractures. On the other hand, a positive correlation was detected between only upper extremity fractures and holidays (Table 1).

In the pre-school group, there were 516 boys and 453 girls; the average age was 4,2-year-old. In the school group, there were 1058 boys and 543 girls; the average age was 9,7-year-old. There was no gender dominance in the pre-school group, but in the school group, there was a boy predominance in both upper and lower extremity fractures (p = 0.001, p = 0.013).

In the pre-school group, there was a negative correlation between CD and upper extremity, lower extremity, and total fractures numbers (p = 0.014, p = 0.029 and p = 0.009). Also, there was the same negative correlation in the school group (p = 0.001, p = 0.027 and p = 0.001) (Table-2).

In the pre-school group, there was no correlation between WD and upper extremity, lower extremity and total fractures numbers (Table-2). There was a positive correlation between WD and upper extremity, and total fractures numbers in the school group (p = 0.015, p = 0.004) (Table-2).

In the pre-school group, there was a positive correlation between HD and upper extremity and total fractures numbers (p = 0.015, p = 0.018). In the school group, there was a positive correlation between HD and upper extremity and total fracture numbers (p = 0.012, p = 0.014). There was no correlation between lower extremity fracture and HD in the two groups (Table-2).

MAT had a positive effect on the upper extremity, lower extremity, and total fracture numbers in the pre-school group (p = 0.028, p = 0.011 and p = 0.010). Also, in the school group, it had a positive effect on upper extremity and total fracture numbers (p = 0.001, p = 0.001) (Table-2).

There was no correlation between fracture numbers and monthly holiday numbers in both groups (Table 2).

In addition, particularly the effects of temperature

Fig. 1. Flow diagram for inclusion or exclusion of study population

Table 1. All children's fractures.

	Monthly Averege Tempterature (°C)		Cold Days (T ≤ 15)		Warm Days (15 < T ≤ 22)		Hot days (T >22)		Holidays	
	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*
Upper Extremity fractures (2195)	0,467	< 0,001	-0,455	< 0,001	0,253	0,013	0,408	< 0,001	0,205	0,045
Lower Extremity fractures (375)	0,342	0,001	-0,336	0,001	0,210	0,040	0,246	0,016	0,100	0,331
Total	0,674	< 0,001	-0,684	< 0,001	0,445	0,029	0,556	0,005	0,203	0,341

and holiday on fractures number, we investigated multivariate effects. We examined how temperature affected when the number of holidays was below fifteen days and fifteen days and more.

In the pre-school group, when the holidays were less than fifteen days, there was no correlation between any fracture site and CD, WD, HD and MAT. However, when the holidays were fifteen days and more, there was a positive correlation between MAT and lower extremity fracture ($p = 0.044$). In addition, another positive correlation between WD and lower extremity and total fractures ($p = 0,010$, $p = 0,022$). In CD, there was a negative correlation between upper extremity and total fracture if there were fifteen or more holidays in a month ($p = 0.025$, $p = 0.025$). There was no correlation between WD and any fracture when the holidays are fifteen or more in a month (Table 3).

In the school group, when the holiday was less than fifteen days (< 15), there was a positive correlation between MAT and upper –total extremity fractures ($p = 0.004$ and $p = 0.001$). A negative correlation between CD and total fracture number ($p = -0.024$) and a positive correlation between WD and upper –total extremity fractures was detected ($p = 0.023$ and $p = 0.010$). There was a positive correlation between HD and lower extremity fractures ($p = 0.045$). In the same group, when the holiday was fifteen days and more (≥ 15), we detected negative correlations with CD and upper-lower extremity and total fractures ($p = 0.025$, *p*

Table 2. Pre-school and school group fractures.

	Monthly Averege Tempterature (°C)		Cold Days (T ≤ 15)		Warm Days (15 < T ≤ 22)		Hot Days (T > 22)		Holidays	
Pre-school group	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*
Upper Extremity fractures (796)	0,448	0,028	-0,495	0,014	0,185	0,387	0,491	0,015	0,240	0,259
Lower Extremity fractures (173)	0,511	0,011	-0,445	0,029	0,100	0,641	0,390	0,060	0,393	0,057
Total (969)	0,517	0,010	-0,521	0,009	0,211	0,323	0,480	0,018	0,241	0,257
School group										
Upper Extremity fractures (1399)	0,651	0,001	-0,641	0,001	0,490	0,015	0,504	0,012	0,233	0,274
Lower Extremity fractures (202)	0,298	0,157	-0,450	0,027	0,404	0,050	0,322	0,125	-0,007	0,974
Total (1601)	0,650	0,001	-0,660	< 0,001	0,560	0,004	0,493	0,014	0,149	0,487

Table 3. Multivariate analaysis of holiday and temperatures.

Upper Extremity fractures			
Group		**Holiday**	***p***
pre-school group	< 15	HD	0,058
	15 ≤	HD	0,072
school group	< 15	WD	0,008
	15 ≤	WD	0,004
		HD	0,001
Lower Extremity fractures			
Group	**Holiday**		***p***
pre-school group	< 15	WD	0,031
		HD	0,069
	15 ≤	HD	0,040
school group	< 15	HD	0,009
	15 ≤	CD	0,011
Total fracture			
Group		**Holiday**	***p***
pre-school group	< 15	HD	0,138
	15 ≤	HD	0,036
school group	< 15	WD	0,004
	15 ≤	MAT	0,066
		CD	0,002

= 0.022 and $p = 0.025$). There was no correlation with MAT, WD, HD and extremity fractures (Table 3).

DISCUSSION

This study showed that weather temperature influences the frequency of the extremity fracture at 2-12 years old. The monthly number of fractures increased in MAT, but typically, they decreased in CD. The changes were clearly observed in the school-age group, in which upper and total extremity fractures increased in WD and HD. All fractures in the pre-school group only increased in HD.

There is a significant correlation between the number of fractures and increased temperature. We thought the main reason for this correlation is related to outdoor physical activities these days. A previous study has shown that children are exhibit less sedentary behaviors and more increased physical activities with warm and windless weather conditions [9]. Unfortunately, children are more likely to fall and cause extremity fractures. Our study showed the linear proportion between the number of the lower extremity fractures and MAT in the pre-school group (who are muscle straight and balance are still developing), but unlikely in the primary school group. It would be appropriate to expect an increase in child fractures in trauma centers in the months when monthly average temperatures increase and plan resources to meet these expectations.

Childhood fractures were classified by whether temperature and showed that the number of fractures was observed on warm days (15Co < T ≤ 25-28 Co), but it was not significantly related to hot days temperature [3, 4, 6-8, 11-14]. The pre-school group who had fractures was not significantly related to warm days. However, in the same group, upper total extremity fractures were significantly related to hot days.

Our study showed that the number of holidays was not a risk factor for the pre-school and school-age groups. The number of holidays greater than 15 days, correlated to lower and total fractures during increased MAT. Additional lower extremity-not total fracture number- fractures were significantly related to the number of holidays less than fifteen days in a month in the primary school group.

Loder *et al*. has reported that the reason for increasing fracture is spent more time in outdoor activities [7]. In many studies, fractures generally occurred on rainless and warm days and suggested that outdoor activities influenced the increased number of fractures [3, 7, 13].

This study has some limitations. First, data were collected retrospectively and several types of fracture were included. Second, we only looked at the temperature variable from the weather conditions, besides, variables such as rain and wind speed can prevent children's outdoor activities, especially. Finally, childhood fractures occur due to multi-factorial causes, and we examined limited variables in this study.

CONCLUSION

In conclusion, there is a close relationship between child extremity fractures and temperature. Extremity fractures in children decrease when the number of cold days in a month increases but increases when the number of warm and hot days increases. Contrary to expectations, the monthly number of fractures is not affected by the number of vacation days per month.

Ethical Approval

The protocol of the study was approved by the Medical Ethics Committee of Bursa Yuksek Ihtisas Training and Research Hospital, Bursa, Turkey. (Decision number: 2011-KAEK-25 2019/04-33, date: April 10, 2019).

Authors' Contribution

Study Conception: NÇ,; Study Design: FT,; Supervision: AÖ,; Materials: NÇ,; Data Collection and/or Processing: YM, UI, HS, TU,; Statistical Analysis and/or Data Interpretation: AÖK,; Literature Review: YA,; Manuscript Preparation: FT and Critical Review: AÖ.

Conflict of interest

No potential conflicts of interest relevant to this article were reported.

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