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Effects of a continental climate on the prevalence and severity of acute non-variceal gastrointestinal bleeding

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ABSTRACT: Seasonal variations in acute gastrointestinal bleeding (AGIB) have rarely been studied, and the published results tend to be contradictory. The aim of this study was to determine the relation between changes in meteorological conditions and the occurrence and severity of AGIB in a continental climate. A retrospective analysis of hospital admissions for AGIB (n = 1033 patients) between 1 January 2010 and 31 December 2012 took into consideration meteorological data obtained from the Hungarian National Meteorology Service. The severity of AGIB and ulcer bleeding was determined by the Glasgow Blatchford score (GBS) and the Forrest classification. No correlations were revealed regarding the monthly and seasonal fluctuations of AGIB, but we did find a significant correlation between the occurrence of AGIB and daily mean temperature. Humidity correlated significantly with the severity of upper gastrointestinal bleeding (UGIB), and meteorological front movement rates were correlated with the number of lower gastrointestinal bleeding (LGIB) cases. Data showed no significant correlations between gastric and duodenal ulcers and climatic factors such as front movement rates, atmospheric pressure, humidity, daily mean temperature and the presence of a full moon.

KEY WORDS: Daily mean temperature · Front movement rate · Ulcer · Humidity · Acute non-variceal gastrointestinal bleeding · Climatic factors

1. INTRODUCTION

Acute gastrointestinal bleeding (AGIB) is a common and challenging emergency, with significant morbidity and mortality. Seasonal variations in AGIB have rarely been studied, and the published results tend to be contradictory. Higher incidences of upper GIB (UGIB) have been reported in winter and spring (Tsai & Lin 1998, Sezgin et al. 2007, Du et al. 2010), whereas others have described a decreased incidence in winter, or no seasonal fluctuations at all (López-Cepero et al. 2005). A significant relationship has been demonstrated between winter and the incidence of peptic ulcers (Yuan et al. 2015) and the incidence of duodenal ulcers, but not the incidence of gastric ulcers (Stermer et al. 1995). Moreover, a correlation has been identified between the incidence of gastric and duodenal ulcers caused by non-steroidal anti-inflammatory drug usage and the cold months in winter and spring (Sezgin et al. 2007), but here as well there have been contrary results (Stermer et al. 1995). An inverse relationship has been demonstrated between the incidence of haematemesis caused by gastric ulcers, vapour

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pressure and mean temperature, and a parallel relation with atmospheric pressure (Nomura et al. 2001).

The publications in which the relationships between AGIB and climatic factors were examined generally related to Mediterranean (Grassi et al. 1993, Thomopoulos et al. 1997, Tenías Burillo et al. 2001, López-Cepero et al. 2005, Sezgin et al. 2007) or subtropical climates (Stermer et al. 1995, Yen et al. 1996, Tsai & Lin 1998, Nomura et al. 2001, Du et al. 2010). No study has been reported on the effects of a continental climate on AGIB. Thus the aim of the present study was to determine the relations between changes in the meteorological conditions and the occurrence and severity of AGIB in an East-Central European region with a continental climate.

2. MATERIALS AND METHODS

Consecutive patients treated in our medical department with acute UGIB or lower GIB (LGIB) between 1 January 2010 and 31 December 2012 were retrospectively analysed. AGIB was defined as blood loss of recent onset from the gastrointestinal tract resulting in instability of vital signs, anaemia and/or the need for blood transfusion. UGIB or LGIB was defined depending on whether the emanation of blood was from a location proximal or distal to the ligament of Treitz. Variceal bleeding was an exclusion criterion because it could distort the results as an independent factor from the climate factors. Urgent endoscopy was performed within 24 h of AGIB. The severity of AGIB was determined by the Glasgow Blatchford score (GBS; Blatchford et al. 2000), and the severity of ulcer bleeding was determined by the Forrest classification (Forrest et al. 1974). The GBS is a risk-stratification system which identifies the necessity of medical intervention such as a blood transfusion or endoscopic intervention.

2.1. Data

Data on the circadian rhythm of the seasons, front movement rates, the presence of a full moon, climatic factors such as daily mean, maximum and minimum temperatures, monthly mean temperature (Fig. 1A), atmospheric pressure (Fig. 1B) and relative humidity (Fig. 1C) for the same period were collected from the Hungarian National Meteorology Service (OMSZ). Hungary is situated between 45° 45′ and 48° 35′ N latitudes, in the west part of Central Europe, about halfway between the Equator and the North Pole, in the temperate climatic zone and is situated in between 3 climatic zones: oceanic, continental and Mediterranean climates. For these reasons, the country can experience extreme differences in the weather. The continental climate in the region of Szeged is typically moderately warm in the dry climate range (Fig. 2A), and the annual precipitation amount is 500–550 mm (Fig. 2B). We calculated the average daily temperatures through use of the daily lowest and highest values measured within 24 h. The incidence of bleeding was recorded each day, the mean was calculated by month, and monthly differences were evaluated. A year was divided into 4 seasonal periods: winter (December–February), spring (March–May), summer (June–August) and fall (September–November), and seasonal differences were also evaluated. Correlations between the incidence and severity of bleeding, anthropometric data and climatic factors were investigated. The area covered by our university hospital serves approximately 400 000 residents.

2.2. Statistical analysis

The demographic data were compared by a chi-squared test, Fisher's exact test and a 2-sample *t*-test. ANOVA and multiple linear regression were used to examine the correlation between climatic factors and the severity of AGIB. Poisson regression was used to describe the dependence of the average number of bleeding cases on several possible risk factors, and a Ljung–Box test was used to determine the autocorrelations. The Spearman correlation was used to determine the extent of the correlation. To perform these tests, we used 1 day (24 h) as the unit of data pooling. Data were processed with SPSS 22.0, and $p < 0.05$ was considered statistically significant.

3. RESULTS

3.1. Incidence of AGIB

This study involved 1033 patients with AGIB: 545 (52.8%) males and 488 (47.2%) females; 529 patients with UGIB and 504 with LGIB. UGIB was more common in men (n = 302, 57.0%) than women (n = 227, 43.0%), while there was no sex difference in LGIB (243 males [48.2%] vs. 261 females [51.8%]). The mean (±SD) ages were 67.5 ± 14.8 yr for UGIB and 66.5 ± 16.4 yr for LGIB. Of the AGIB and UGIB cases,

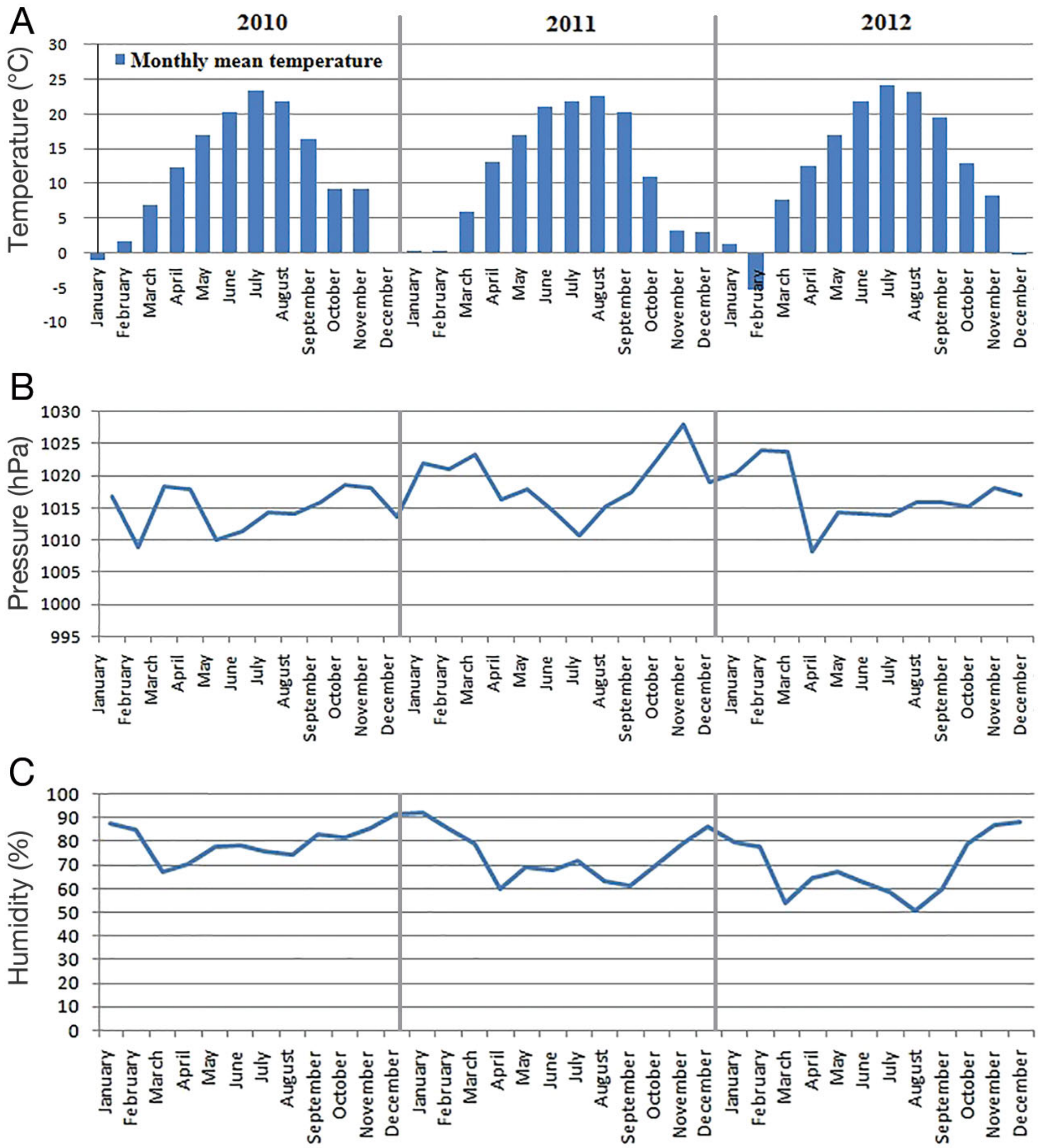

Fig. 1. Monthly mean (A) temperature, (B) atmospheric pressure and (C) humidity in the region of Szeged, Hungary, in 2010–2012

85.7 and 84.1%, respectively, occurred in people older than 50 yr, with a peak incidence during the 6th decade in males and during the 8th decade in females for AGIB, and during the 6th decade in males and the 7th decade in females for UGIB. Patient gender and age appeared to influence the incidence of AGIB. We found a higher incidence of AGIB with the progress of age in males ($n = 1033$; gender $p = 0.003$; age $p < 0.0001$).

The data on the diagnoses of UGIB and LGIB are depicted in Tables 1 & 2. The exact source of the bleeding was not found in 7.2% of the UGIB and in 17.8% of the LGIB cases.

The incidence of UGIB seemed to be higher during fall and winter, especially from October to December, although the difference was not statistically significant ($n = 529$; $p = 0.086$, Fig. 3). Similarly, there was no significant difference in the seasonal occurrence of LGIB ($n = 504$; $p = 0.246$; Fig. 3), or in the monthly incidence of either UGIB or LGIB ($n = 529$; $p = 0.227$, $n = 504$ $p = 0.318$; Fig. 4).

The incidences of gastric and duodenal ulcers among the causes of UGIB were separately analysed (Figs. 5 & 6). The occurence of gastric ulcers peaked in February and November, while duodenal ulcers peaked in May and October, but the monthly inci-

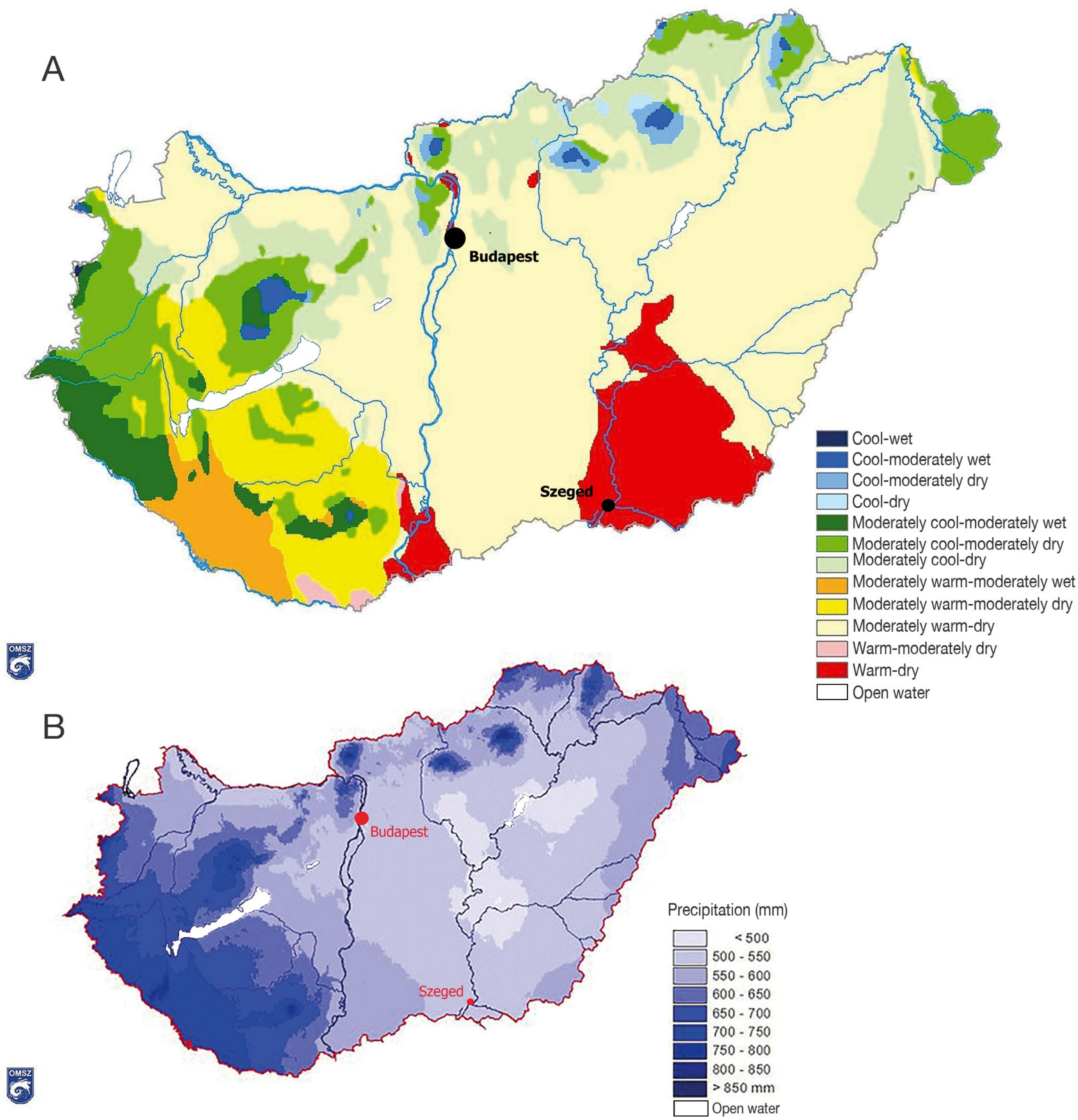

Fig. 2. (A) Climatic regions of Hungary (after the Hungarian National Meteorology Service [OMSZ] and György Péczeli). (B) Average annual precipitation in Hungary based on the 1971–2000 period (after OMSZ)

dence was not statistically significant (n = 138; p = 0.386 and n = 122; p = 0.679).

We found a significant relationship between the daily mean temperature and the occurrence of AGIB (n = 1033; p = 0.017). Moreover, the data showed a significant connection between front movement rates and the number of LGIB cases (n = 504; p = 0.018) but not UGIB cases (n = 529; p = 0.911; Table 3). Humidity and atmospheric pressure (data not shown) did not have an effect on the incidence of AGIB or UGIB and LGIB. Autocorrelation was not revealed in a 16 d long period during the examination of a weekend effect on the incidence of AGIB periods.

Furthermore, significant correlations were not found between gastric and duodenal ulcers and climatic factors such as front movement rates, atmospheric pressure, humidity, daily mean temperature and the presence of a full moon (data not shown).

Table 1. Diagnoses and distribution of upper gastrointestinal bleeding (UGIB). The exact source of the bleeding was not found in 37 patients with UGIB

Diagnoses	Number of patients Male	Female
Gastric ulcer	75	52
Duodenal ulcer	66	51
Erosive gastritis	51	37
Gastroesophageal reflux disease	21	16
Mallory-Weiss syndrome	17	12
Gastric adenocarcinoma	12	8
Angiodysplasia	9	11
Portal hypertensive gastropathy	10	6
Other tumours	8	7
Bleeding after endoscopic sphincterotomy	5	4
Polyp	2	4
Gastric antral vascular ectasia	3	1
Haemosuccus pancreaticus	1	0
Barrett's esophagus	1	0
Diverticulum pylori	0	1
Aortoduodenal fistula	1	0

Table 2. Diagnoses and distribution of lower gastrointestinal bleeding (LGIB). The exact source of the bleeding was not found in 89 patients with LGIB

Diagnoses	Number of patients Male	Female
Haemorrhoids	61	74
Diverticulum	49	42
Colorectal cancer	35	28
Colitis	17	24
Polyp	14	19
Radiation proctitis	9	11
Angiodysplasia	7	5
Anal fissure	7	4
Postpolypectomy bleeding	2	2
Crohn disease	1	3
Aortojejunal fistula	1	0

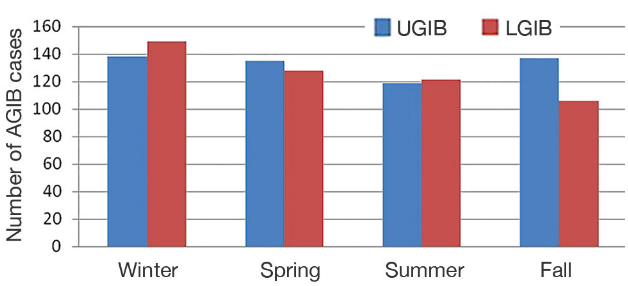

Fig. 3. Cumulative seasonal fluctuation of lower (LGIB) and upper gastrointestinal bleeding (UGIB) among 1033 patients treated between 1 January 2010 and 31 December 2012. AGIB: acute gastrointestinal bleeding

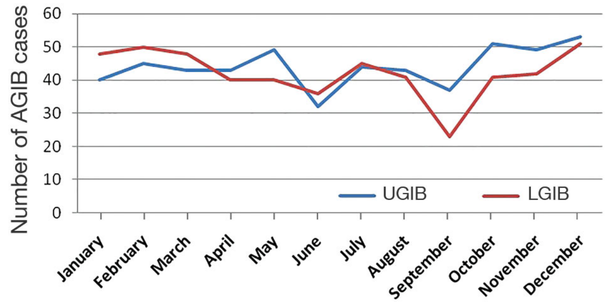

Fig. 4. Cumulative monthly incidence of lower (LGIB) and upper gastrointestinal bleeding (UGIB) among 1033 patients treated between 1 January 2010 and 31 December 2012. AGIB: acute gastrointestinal bleeding

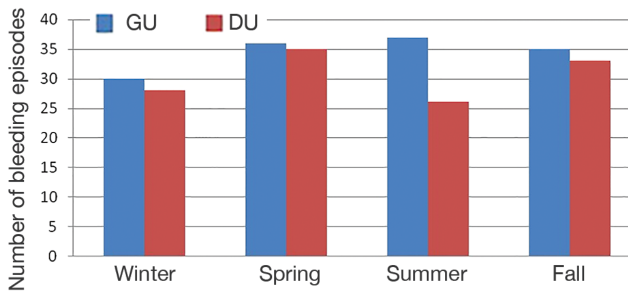

Fig. 5. Cumulative seasonal fluctuation of gastric (GU) and duodenal ulcers (DU) among 1033 patients treated between 1 January 2010 and 31 December 2012

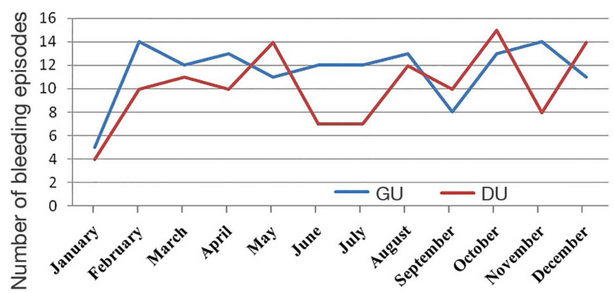

Fig. 6. Monthly variation in the incidence of gastric (GU) and duodenal ulcer (DU) bleeding among 1033 patients treated between 1 January 2010 and 31 December 2012

3.2. Severity of AGIB

The severity of ulcer bleeding was determined by the Forrest classification (Table 4) and the severity of AGIB by the GBS (Table 4). The GBS was significantly elevated with age in males (gender $r = 0.304$; $p < 0.0001$, age $r = 0.01$; $p < 0.0001$). Humidity was significantly correlated with the severity of UGIB measured by the GBS ($r = 0.308$, $p = 0.005$), but not by the Forrest classification ($n = 260$; $p = 0.22$). However, there was no significant relationship between other

Table 3. Numbers of upper (UGIB) and lower gastrointestinal bleeding (LGIB) cases, showing influence of meteorological front impact among 1033 patients treated between 1 January 2010 and 31 December 2012. Examined types of front impact included stable warm and cold front impact, unstable warm and cold front impact and dual front impact

Seasons	UGIB cases		LGIB cases	
	Front impact	Without front impact	Front impact	Without front impact
Winter	85	54	90	60
Spring	71	66	75	52
Summer	61	56	52	69
Fall	79	57	51	55

Table 4. Severity of bleeding. Ulcer bleeding according to the Forrest classification—I/a: acute haemorrhage (spurting); I/b: acute haemorrhage (oozing); II/a: signs of recent haemorrhage (visible vessel); II/b: signs of recent haemorrhage (adherent clot); II/c: signs of recent haemorrhage (flat pigmented haematin on ulcer base); III: lesions without active bleeding. Acute gastrointestinal bleeding (AGIB) according to the Glasgow-Blatchford score

Severity (%)					
Ulcer bleeding					
I/a	I/b	II/a	II/b	II/c	III
9.50	24.44	11.76	16.28	13.12	24.90
AGIB					
Low risk for intervention (score = 0)					14.13
Increased risk for intervention (0 < score ≤5)					36.78
High risk for intervention (score > 5)					49.09

climatic factors, including front movement rates, atmospheric pressure, daily mean temperature and the presence of a full moon and the GBS or Forrest classification. We did not find any significant seasonal or monthly differences in the severity of UGIB ($p = 0.262$).

4. DISCUSSION

Conflicting results have been reported regarding the seasonal fluctuations of AGIB. Those publications analysed the effects of Mediterranean (Grassi et al. 1993, Thomopoulos et al. 1997, Tenías Burillo et al. 2001, López-Cepero et al. 2005, Sezgin et al. 2007) and subtropical (Stermer et al. 1995, Yen et al. 1996, Tsai & Lin 1998, Nomura et al. 2001, Du et al. 2010) climates on AGIB. Higher incidences of UGIB have been described during winter and early spring (from December to April) (Stermer et al. 1995, Du et al. 2010), from November to March (Tsai & Lin 1998), in fall and winter (Nomura et al. 2001) and in March (Sezgin et al. 2007) in subtropical climates. In Mediterranean climates, no seasonal or monthly fluctuation of UGIB was reported (López-Cepero et al. 2005, Sezgin et al. 2007), or there was a seasonal fluctuation of duodenal ulcers with the lowest prevalence during winter (Thomopoulos et al. 1997), or in contrast, with the highest incidence of duodenal ulcers in fall and winter (Tenías Burillo et al. 2001).

The effects of a continental climate on AGIB have not been examined. Our study revealed that the incidence of UGIB and LGIB was higher in the cold months, but these differences were not statistically significant. Similarly, there was no seasonal or monthly fluctuation in the prevalence of gastric or duodenal ulcers. The absence of seasonal fluctuations in the prevalence of UGIB might be explained by the presence of contradictory factors which act against one another. For example, *Helicobacter pylori* infection is significantly more common in winter (Moshkowitz et al. 1994), and vitamin C deficiency is more frequent in winter (Ozyilkan et al. 1994). Furthermore, the intake of salicylate drugs increases in winter (Langman 1964), and cold stress tests have demonstrated increased mucosal damage to the duodenum in mice (Natelson et al. 1979). These factors may increase the occurrence of UGIB in winter. In contrast, the volume and acidity of gastric secretions are higher in fall (Mizell 1955, Hui & Lam 1987).

Our study revealed a higher incidence of AGIB with progressive age in males. The occurrence of AGIB was related to daily mean temperature, and the occurrence of LGIB to front movement rates. The marked temperature increase in the spring season, and the significant temperature decrease during the fall months in a continental climate may also increase the number of AGIB events. Annually, >200 fronts pass over Hungary. The high numbers of cold fronts during spring and warm fronts during fall could increase the incidence of AGIB (Faragó et al. 2010). The lowest number of front movements was observed in August, when the number of AGIB events was also the lowest. The changes in atmospheric pressure in Hungary are greatest during spring and fall, and this may also increase the prevalence of AGIB. The monthly average atmospheric pressure decreases during summer (Busuioc et al. 2007), when the lowest incidence of AGIB was detected.

The correlation between temperature and the incidence of AGIB is conflicting and seems to be distinct in different climates. In contrast to our results, an inverse relation was demonstrated between the incidence of gastric ulcers and mean temperatures in a humid subtropical climate zone with hot humid summers and generally mild winters (Stermer et al. 1995, Nomura et al. 2001). Furthermore, a relation was revealed between the prevalence of gastric ulcers and atmospheric pressure (Nomura et al. 2001).

To our knowledge, the effects of climatic factors on the severity of AGIB have not been published previously. We demonstrated that humidity is significantly correlated with the severity of UGIB as measured by the GBS. A low humidity level increases the risk of thrombogenesis (Yamashita et al. 2005) and the rate of cardiovascular mortality (Sharovsky et al. 2004, Abrignani et al. 2009, 2012, Ou et al. 2014). In contrast, the evaporation rate of the plasma decreases and the coagulation time is extended at elevated humidity levels (Yao et al. 2013). It may be presumed that a high level of humidity enhances the severity of bleeding by prolonging the coagulation time.

However, there are some limitations of this study. A larger daily sample size and more yearly replication covering longer-term dynamics are desirable. Furthermore, the effects of age structure, occupation and income on the relationship between the prevalence of AGIB and the climatic factors have not been studied. Farmers, patients from rural areas or those with lower income may seek medical care later.

5. CONCLUSIONS

Seasonal fluctuations in the prevalence of AGIB could not be demonstrated in this continental climate. However, we did find a relationship between the occurrence of AGIB and daily mean temperatures, and the occurrence of LGIB and front movement rates. Humidity was correlated with the severity of UGIB.

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