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LOW ATMOSPHERIC PRESSURE AND HUMIDITY ARE RELATED WITH MORE FREQUENT PULMONARY EMBOLISM EPISODES IN MALE PATIENTS

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Abstract: Pulmonary embolism is a frequent condition, related with high mortality. Frequency of pulmonary embolism episodes has been related with several meteorological factors. The aim of the study was to analyze the influence of meteorological factors on the occurrence of pulmonary embolism in male and female patients. Medical data of patients hospitalized at our institution in 2007–2008 was analyzed. Study group included 400 patients with pulmonary embolism, living in the region located at an average level of about 200 m above sea level, with climate of a transitional character between maritime and continental climates. No significant differences in seasonal distribution of pulmonary embolism episodes were observed. A significant inverse correlation of the number of pulmonary embolism cases and atmospheric pressure, as well as air humidity, was identified in male patients. No significant correlations of temperature, wind velocity, precipitation and number of PE cases were observed. The influence of meteorological factors on the occurrence of pulmonary embolism in males is a new finding. A prospective study is warranted to further analyze this result.

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INTRODUCTION

The influence of environmental factors on the incidence of cardiovascular events is well known. In particular, meteorological conditions have been attributed to acute coronary syndromes, stroke and arrhytmias. Few reports have been published on the influence of meteorological parameters to the occurrence of acute pulmonary embolism. Acute PE is an important public health problem, with high mortality reaching 11% [16], and is reported in more than 30% of acute hospital care deaths [11]. Approximate morbidity reported for Poland reaches 90,000 cases/year [14].

Gender differences in health response and morbidity to meteorological conditions are a new issue in studies on the relationship between weather and disease. The aim of the study was to compare the meteorological factors in male and female patients of the University Hospital in periods of high and low occurrence of PE.

MATERIAL AND METHODS

Medical documentation of 1,098 patients with suspected acute pulmonary embolism (PE) diagnosed between January 2007–December 2008 was retrospectively analyzed.

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Patients with PE confirmed by CT pulmonary angiography were included for further analysis. Inclusion criterion was a PE episode diagnosed for the first time in the lifetime. The exclusion criteria were: chronic PE diagnosed by means of CT pulmonary angiography, history of acute PE, and the distance of more than 100 km from the hospital to the place of residence. PE was confirmed in 400 patients, 177 females (aged 68.1±15.7) and 223 males (aged 65.6±15.3). The hospital is a tertiary care academic institution, serving a city of 350,000 inhabitants and the adjacent area. The city is located at 51°14' N 22°34' E, at the mean height of about 200 m above the sea level. Sixty-two percent of patients included in the study were inhabitants of the urban area at the distance of less than 20 km from the hospital, and 36% lived within a 45 km radius of the city centre.

The following meteorological data were collected from the relevant time period: temperature, humidity, precipitation, pressure and wind velocity. Hence, the exact time of PE onset was unknown; the meteorological values attributed to each patient were means of the values in 3 days preceding the time of diagnosis of PE, as suggested elsewhere [15]. Risk factors or comorbidities were not analyzed in this study.

Statistical methods. Pearson's chi-square test was used to compare the number of patients presenting with PE in each season. The Pearson correlation (r) was used to determine the relation between the mean weekly values of meteorological parameters and PE frequency for each season. Weeks with high and low frequency of PE episodes were distinguished based on the histogram (cutoff value: 2 PE cases/week), and the differences of meteorological parameters were assessed with Mann-Whitney test; p value <0.05 was considered as indicating statistical significance. Data was analyzed using SPSS 17.0 statistical software. The study was performed in compliance with the relevant local and international law, as well as institutional guidelines.

Table 1. Pearson correlation of weekly number of PE cases with meteorological parameters. Significant correlations marked with asterisk and in bold.

No. of PE cases/week:		Temperature	Humidity	Precipitation	Atmospheric pressure	Wind velocity
Males	r	0.024	**-0.208***	-0.027	**-0.262****	0.054
	p	0.809	**0.034**	0.788	**0.007**	0.587
Females	r	0.106	-0.003	0.048	-0.024	-0.194
	p	0.282	0.978	0.626	0.810	0.068
Total	r	0.078	-0.153	0.007	**-0.197***	-0.091
	p	0.430	0.119	0.941	**0.044**	0.357

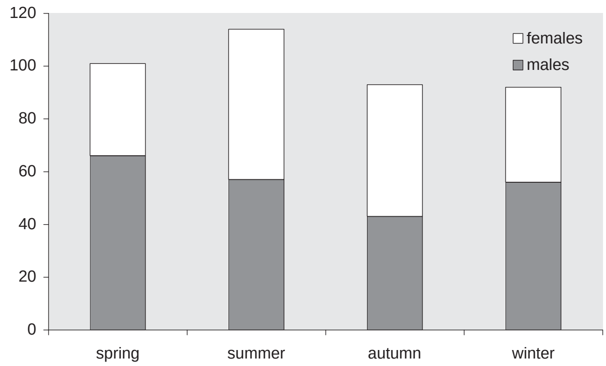

Figure 1. Number of patients with confirmed PE in the study period. No significant seasonality of number of PE cases was observed (χ^2=3.160, p=0.368).

RESULTS

Seasonal distribution of the confirmed PE cases is presented at Figure 1. No significant difference of frequency of PE episodes between the seasons was observed (χ^2=3.160, p=0.368). Pearson correlation of the meteorological data with the number of PE cases per week was calculated. In male patients, a significant inverse correlation (r=-0.208,

Table 2. Descriptive statistics of meteorological parameters in weeks with low and high PE occurrence in male and female patients. Significant differences in bold.

	Low PE occurrence			High PE occurrence			p
	Median	Min	Max	Median	Min	Max	
Male							
Temperature [°C]	7.00	-5.86	22.14	10.29	-6.71	23.86	0.299
Humidity [%]	**81.14**	42.57	94.57	**72.93**	43.71	94.29	**0.018**
Precipitation [mm]	0.57	0.00	6.00	0.64	0.00	4.43	0.905
Atmospheric pressure [hPa]	**1,017.86**	998.86	1,037.00	**1,014.14**	997.29	1,028.00	**0.009**
Wind velocity [km/h]	8.43	4.14	18.71	8.07	5.00	15.29	0.362
Female							
Temperature [°C]	10.71	-6.71	22.29	10.29	-2.29	23.86	0.922
Humidity [%]	74.29	40.71	94.57	80.57	58.71	94.29	0.239
Precipitation [mm]	0.57	0.00	6.00	0.71	0.00	4.43	0.369
Atmospheric pressure [hPa]	1,016.43	997.29	1,037.00	1,014.00	1,008.00	1,033.00	0.146
Wind velocity [km/h]	8.14	4.43	18.71	8.00	4.14	15.29	0.319

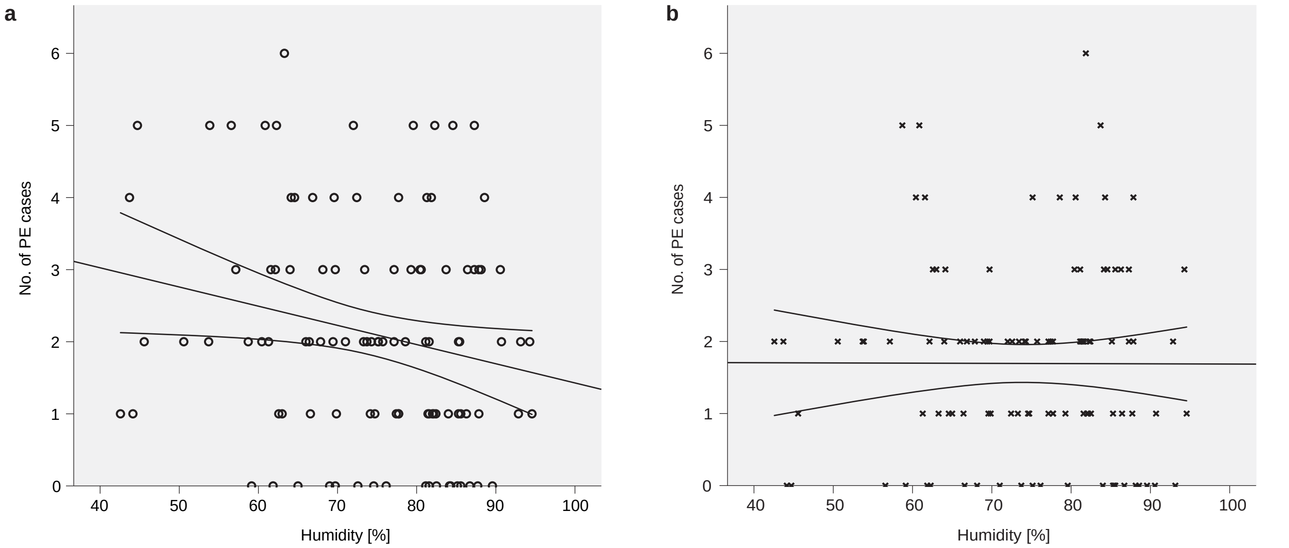

Figure 2. Pearson correlation with 95% prediction range between number of PE cases per week and mean weakly humidity. (a) males – p=0.018; (b) females – p=NS.

p=0.034) between the number of PE cases and humidity was observed (Fig. 2), as well as a highly significant (p=0.007) inverse correlation with atmospheric pressure (Fig. 3). No such correlations were observed in female patients. A significant inverse correlation of atmospheric pressure and number of PE cases was observed for the whole group; however, the statistical significance was lower than that calculated for male patients only. Detailed results of the analysis are presented in Table 1. The number of PE cases in each week of the studied period was recorded. Results of the analysis are presented in Table 2. Significantly lower values of humidity and atmospheric pressure were observed in weeks with a high PE occurrence (Fig. 4). The seasonal distribution of PE in males and seasonal values of humidity and atmospheric pressure are presented in Figure 5.

DISCUSSION

The first observation on the weather's influence on health is attributed to Hippocrates [7]. Seasonality and impact of weather on cardiovascular disorders has been under extensive research for years. Goerre *et al.* [6] analyzed the impact of weather conditions and climate on the incidence of acute coronary syndromes (ACS). Their study, which included 6,560 patients hospitalized due to myocardial infarction, revealed that the high ambient pressure, high pressure gradients and heavy wind activity was associated with an increase of the number of ACS cases. Dawson *et al.* [1] analyzed changes in weather conditions and compared them to hospital admissions due to cerebrovascular incidents. In conclusion, they stated that every 1°C increase in mean

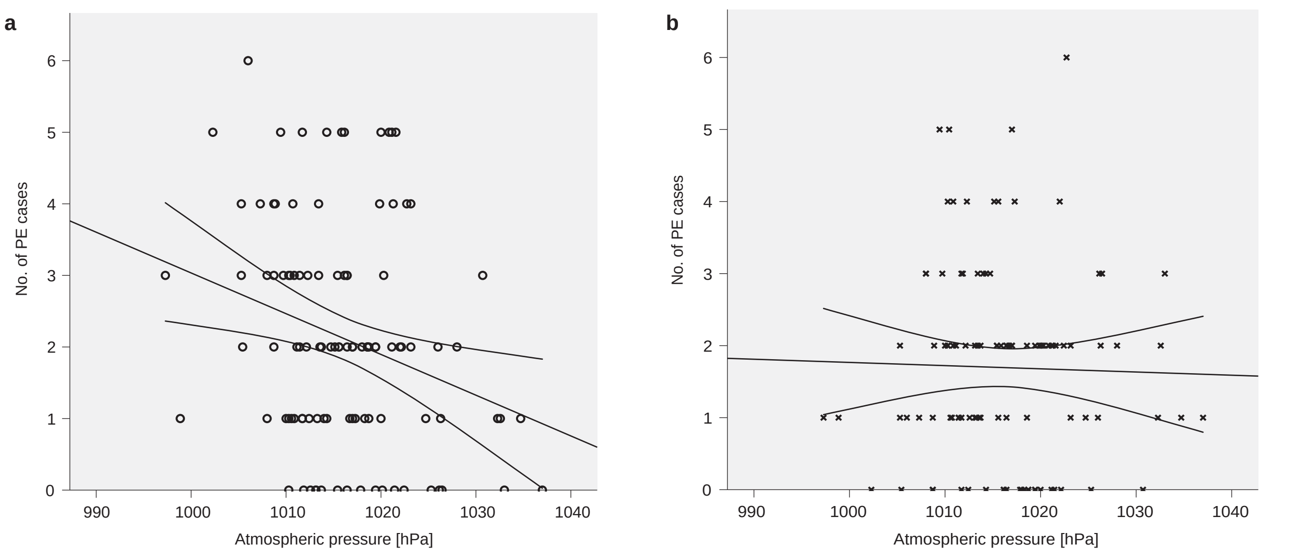

Figure 3. Pearson correlation with 95% prediction range between number of PE cases per week and mean weakly atmospheric pressure. (a) males – p=0.009; (b) females – p=NS.

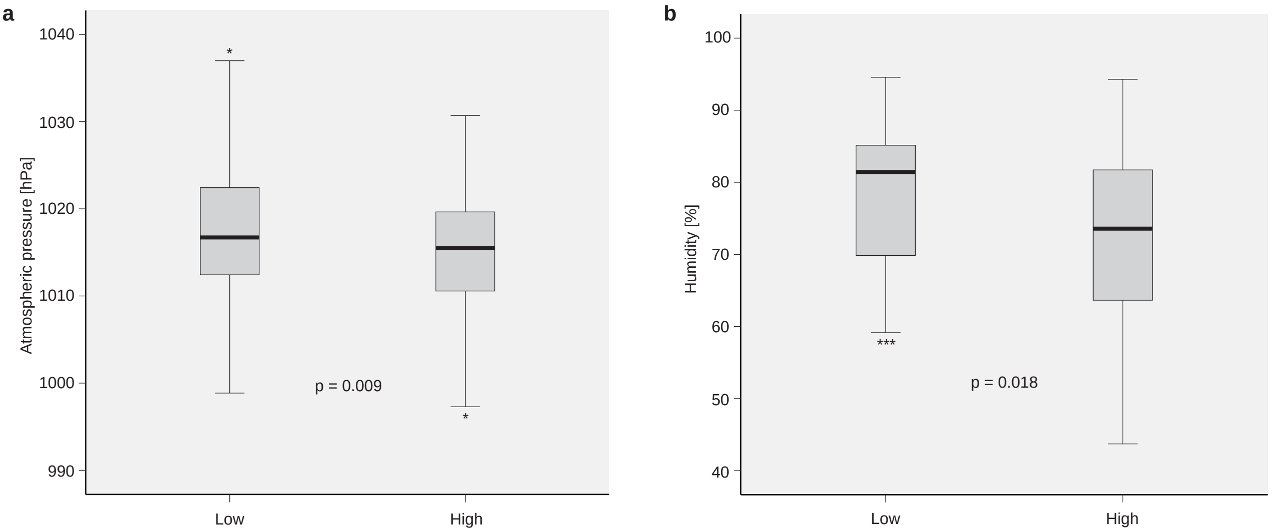

Figure 4. Boxplot graph of meteorological parameters in weeks with low and high prevalence of PE in males. Black asterisks – outliers. (a) atmospheric pressure; (b) humidity.

temperature during the preceding 24 hours was associated with a 2.1% increase in ischemic stroke admissions, whereas a fall in atmospheric pressure over the preceding 48 hours was associated with an increased rate of hemorrhagic stroke admissions. Feigin *et al.* [3] revealed the correlation between occurrence of ischemic stroke and low relative humidity. Additionally, the authors observed a trend indicating an increase in the number of strokes in low ambient temperatures.

Reports on gender-related differences in the influence of weather on morbidity are frequently focused on cardiovascular disorders. Recently, Gluszak *et al.* [5] analyzed the correlation between intensity of sunshine and number of atrial fibrillation episodes in a similar region of eastern Poland. They revealed different seasonal distribution of atrial fibrillation episodes between genders, and also stated that such seasonal distribution could be attributed to different intensities of exposure to sunshine.

There is no consensus on the seasonality of PE occurrence between researchers. Masotti *et al.* [9], in a study conducted in Italy, revealed an increased occurrence of PE in surgical patients (general surgery and orthopedics) during cold months, as well as during longer periods of hospitalization of those patients in the same season. The same study showed increased number of PE incidents during warm months in the cardiology ward. Manfredini *et al.* [8], in a study of over 700 cases, confirmed the existence of a seasonal variation of PE episodes. A peak number of PE cases occurred in winter, independent of patients' underlying risk comorbid conditions. The study by Galleriani *et al.* [4] analyzed 19,245 cases of pulmonary embolism in the Emilia Romagna region of Italy. The number of PE incidents recorded in that study varied according to the season, with the lowest number in the spring and the highest in the winter. On the contrary, Stein *et al.* [16], who performed a large population study in the United States, did not observe a seasonal variation of PE episodes. In our material, the peak occurrence of PE in the whole population was in summer and spring in males; however, the difference in seasonal distribution was not statistically significant in either of the gender groups, or the whole group.

In our study, a significant inverse correlation was observed between air humidity and the number of PE cases per week.

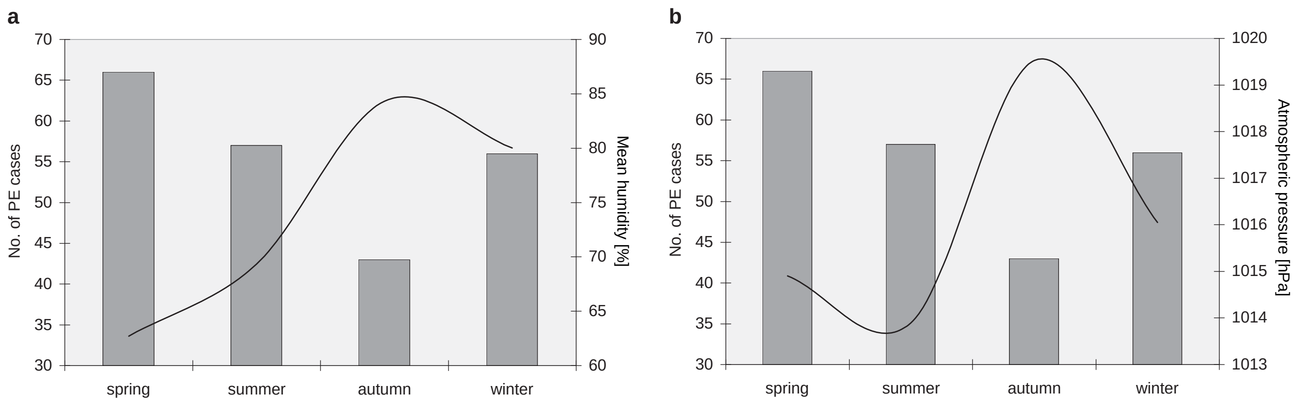

Figure 5. Number of PE cases in male patients in the study period (bars). Lines present (a) mean humidity [%] and (b) atmospheric pressure [hPa] in the respective seasons. Seasonal variance of number of PE episodes was not statistically significant. However, seasons with a high number of PE episodes are characterized by low mean atmospheric pressure and low humidity.

Massoti *et al.* [9] also reported a weak inverse correlation (r=-0.38) between these parameters; however, in our study such a correlation was observed in male patients only.

Low atmospheric pressure has been related to an increased occurrence of cardiovascular and pulmonary episodes [12]. One of the first reports describing the influence of atmospheric pressure on the occurrence of PE episodes was published by De Takats *et al.* [2] who observed an increase in the number of PE episodes in periods of low atmospheric pressure. We observed significantly lower atmospheric pressure values in weeks with a low number of PE episodes in male patients, and a significant inverse correlation between these two parameters. Concordant results were obtained by Massoti *et al.* [9], who showed a strong inverse correlation between mean monthly temperature and atmospheric pressure, and the number of cases of PE. Similar findings were presented in the study by Meral *et al.* [10] conducted in eastern Turkey, which evaluated the relationship between atmospheric pressure and the incidence of PE. An inverse correlation between PE frequency and average atmospheric pressure was found (r=-0.70; p<0.01) in this study. On the contrary, Őztuna *et al.* [13] in their study of 206 patients, carried out at the seaside region of eastern Turkey, observed a positive correlation between air pressure as well as humidity and number of PE cases; however, the authors admitted that such a difference might have resulted from climatic differences in the study centres, and their geographical structures.

Identification of high frequency of PE occurrence in periods of low atmospheric pressure or low humidity requires further study, as a decrease in atmospheric pressure is usually followed by an increase in humidity. The possible explanation of such a coincidence is that increased PE frequency occurs in periods of dynamic weather changes. Thus, the results of this study show the need for further research.

In conclusion, a statistically significant inverse correlation between atmospheric pressure and humidity and the number of PE cases were observed in our study, which is in accordance with other reports. However, our paper brings a new insight into the nature of this correlation, as it shows that significant correlations occur exclusively in males. A prospective study should be undertaken to clarify this gender-related difference.

REFERENCES

1. Dawson J, Weir C, Wright F, Bryden C, Aslanyan S, Lees K, Bird W, Walters M: Associations between meteorological variables and acute stroke hospital admissions in the west of Scotland. *Acta Neurol Scand* 2007, **117**, 85–89.
2. De Takats G, Mayne A, Petersen WF: The meteorological factor in pulmonary embolism. *Surgery* 1940, **7**, 819–827.
3. Feigin VL, Nikitin P, Bots ML, Vinogrodova TE, Grobbee DE: A population-based study of the associations of stroke occurrence with weather parameters in Siberia, Russia (1982–1992). *Eur J Neurol* 2001, **7**, 171–178
4. Gallerani M, Boari B, Smolenski MH, Salmi R, Fabbri D, Contato E, Manfredini R: Seasonal variation in occurence of pulmonary emboliom: analysis of the database of the Emilia-Romagna Region, Italy. *Chronobiol Intern* 2007, **25**, 143–160.
5. Gluszak A, Kocon S, Szaniawska E, Zuk K, Aljabali P, Gluza A, Siwek K: May sunshine protect women against paroxysms of atrial fibrillation? *Tohoku J Exp Med* 2009, **219**, 303–306.
6. Goerre S, Egli C, Gerber S, Defila C, Minder C, Richner B, Meier B: Impact of weather and climate on the incidence of acute coronary syndromes. *Int J Cardiol* 2007, **118**, 36–40.
7. Kevan SM: Quests for cures: a history of tourism for climate and health. *Int J Biometeorol* 1993, **37**, 113–124.
8. Manfredini R, Gallerani M, Boari B, Salmi R, Mehta RH: Seasonal variation in onset of pulmonary embolism is independent of patients' underlying risk comorbid conditions. *Clin Appl Thromb Hemost* 2004, **10**, 39–43.
9. Masotti L, Ceccarelli E, Forconi S, Cappelli R: Seasonal variations of pulmonary embolism in hospitalized patients. *Resp Med* 2005, 99, 1469–1473.
10. Meral M, Mirici A, Asian S, Akgun M, Kaynar H, Saglam L, Gorguner M: Barometric pressure and the incidence of pulmonary embolism. *Chest* 2005, **128**, 2190–2194.
11. Nordstrom M, Lindblad B: Autopsy-verified venous thromboembolism within a defined urban population – the city of Malmo, Sweden. *APMIS* 1998, **106**, 378–384.
12. Őzpolat B, Gözübüyük A, Koçer B, Yazkan R, Dural K, Genç O: Meteorological conditions related to the onset of spontaneous pneumothorax. *Tohoku J Exp Med* 2009, **217**, 329–334.
13. Őztuna F, Őzsu S, Topbaş M, Bülbül Y, Koşucu P, Őzlü T: Meteorological parameters and seasonal variations in pulmonary thromboembolism. *Am J Emerg Med* 2008, **26**, 1035–1041.
14. Piekut K, Kulesza-Brończyk BE, Piechocka DI, Terlikowski SJ: The role of education in venous thromboembolism prevention in obstetrics. *Zdr Publ* 2009, **119**, 442–445.
15. Scott JA, Palmer EL, Fischman AJ, Strauss HW: Meteorologic influences on the frequency of pulmonary embolism. *Invest Radiol* 1992, **27**, 583–586.
16. Stein PD, Kayali F, Olson RE: Analysis of occurrence of venous thromboembolic disease in the four seasons. *Am J Cardiol* 2004, **93**, 511–513.