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Evaluating Weather's Effect on Fibromyalgia Patients Using the Revised Fibromyalgia Impact Questionnaire and the Brief Pain Inventory

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Abstract

Background: The objective of this study was to evaluate weather's effect on fibromyalgia symptoms as measured by the Revised Fibromyalgia Impact Questionnaire (FIQR) and the Brief Pain Inventory (BPI), which had not been reported previously.

Methods: 67 patients with fibromyalgia from the Ohio State University Rheumatology clinic were recruited for the study. We received survey results back from 30 patients. Patients were given questionnaires for the FIQR and BPI to fill out for 7 consecutive days. Data was collected from February 1, 2015 through February 7, 2015. We recorded daily weather parameters (temperature, humidity, and barometric pressure) for Columbus Ohio from the National Weather Service website beginning on January 31, 2015 to February 8, 2015. Linear correlations between the weather parameters, FIQR, and BPI were done using Pearson correlation coefficient. Analysis of covariance (ANCOVA) was used to correlate each patient trend with the weather parameters. Finally, principal component analysis (PCA) was used to recognize patterns in our data.

Results: We found no significant effect of weather on fibromyalgia symptoms using ANCOVA as measured by FIQR and BPI. PCA showed weak significant correlations between the second and the third principal components with the barometric pressure (0.26) and the humidity (-0.15), respectively.

Conclusion: We did not find any statistically significant effect of weather on fibromyalgia symptoms as measured by FIQR and BPI. PCA of the FIQR and BPI showed low correlation with barometric pressure and humidity but they accounted for only 6.6% and 5% of the variability in our dataset, which are too low to extract strong conclusions from.

Keywords: Fibromyalgia; Weather; Barometric pressure

Abbreviations ACR: American College of Rheumatology; FIQR: Revised Fibromyalgia Impact Questionnaire; FM: Fibromyalgia; BPI: Brief Pain Inventory; PCA: Principal Component Analysis, ANCOVA: Analysis of Covariance.

Background

Patients with rheumatic diseases often report worsening of their pain associated with weather changes. Various reports have estimated an incidence of 34%-69% in arthritic patients complaining of worsening pain associated with changes in weather [1]. Results of studies evaluating weather's effect on rheumatic patients have been contradictory [1]. Animal studies in barometric chambers with rat and pig models have shown that lowering the barometric pressure intensifies pain related behavior in the animals [2,3]. However in human studies done with arthritis patients in a weather chamber by Hollander in the 1960s did not show changes in pain levels with individual variations in the barometric pressure, humidity, temperature, rate of air flow, or air ionization. In 1963, Hollander and Yeostros did find that the combination of rapid changes of falling barometric pressure and high humidity increased the perception of pain in a small sample size of 12 patients [4].

Patients with fibromyalgia commonly report exacerbation of symptoms with weather changes [5]. Up to 92% of fibromyalgia patients associate change in weather with worsening of their symptoms [6]. Anecdotally, this complaint is so common that some authors in the past suggested this as part of the diagnosis for fibromyalgia [7,8]. However, studies done on evaluating how weather affects fibromyalgia symptoms have shown mixed results [6]. The American College of Rheumatology's first proposed diagnostic criteria for fibromyalgia in 1990 and subsequent revised preliminary diagnostic criteria for fibromyalgia in 2010 do not include weather's effect on pain level as part of the diagnostic criteria [9,10].

A PubMed search yielded 8 studies evaluating weather's effect on fibromyalgia patients [6,11-16]. The results of the 8 studies are as follows. In 1990, Guedj and Weinberger published a study of 62 patients (16 with rheumatoid arthritis, 24 with osteoarthritis, 11 with inflammatory arthritis, and 11 with fibromyalgia) evaluating pain, swelling, and everyday activity compared with changes in daily

weather conditions [11]. Analysis showed pain was significantly affected by barometric pressure in fibromyalgia. Blecourt et al. published a study in 1993 involving 50 fibromyalgia patients [12]. Results showed no significant relationship between weather factors and the symptom scores. Hagglund et al. published a study in 1994 involving 84 fibromyalgia patients [13]. This study also did not find any significant relationship between weather and disease severity. Fors and Sexton published a study in 2001 of 61 fibromyalgia patients [14]. Once again, analysis did not find any significant weather influence on fibromyalgia symptoms.

Strusberg et al. published a study of 151 patients (52 with osteoarthritis, 82 with rheumatoid arthritis, 32 healthy subjects, and 17 with fibromyalgia). He found low temperature and high atmospheric pressure were significantly associated with fibromyalgia pain levels [15]. Smedslund et al. published a study of 50 fibromyalgia patients, which showed a significant impact of barometric pressure on pain scores [16].

Bossema et al. published a study involving 333 fibromyalgia patients in 2013 [6]. They found that in some patients, each 1 h increase in sunshine duration was associated with lower levels of pain, 1% increase in humidity was associated with increase in pain, and each 1 degree Celsius increase in temperature was associated with higher fatigue levels. However, analysis also showed that in 1/3 of patients there was no relationship between weather variable and symptoms, in another 1/3 of patients a positive relationship to weather was found, and in the remaining 1/3 of patients a negative relationship to weather was found. So the authors ultimately concluded in their paper that there is more evidence against than in support of influence of weather on fibromyalgia symptoms.

Most recently, Vincent et al. published data in March 2016 showing that a variety of factors contribute to fibromyalgia flares including weather changes. Their qualitative study describing the patient experience of a fibromyalgia flare found that patients attribute 25% of all flares to weather changes.

Although these eight studies described above have examined the possible association of weather parameters to changes in fibromyalgia symptoms, we wanted to examine this topic ourselves but using the Revised Fibromyalgia Impact Questionnaire (FIQR) and the Brief Pain Inventory (BPI), which have not been done before. Since the publication of the Fibromyalgia Impact Questionnaire (FIQ) in 1991 and subsequent revisions in 1997, 2002, and most recently in 2009, it has become a common validated tool to use in fibromyalgia research [17-19].

Methods

We recruited 67 female patients with fibromyalgia, who all met the 1990 American College of Rheumatology classification criteria for fibromyalgia, from the Ohio State University Rheumatology clinic to participate in the study. Patients were aware that this study was about weather's effect on fibromyalgia symptoms. Patients were given questionnaires for the FIQR and BPI to fill out every day for 7 consecutive days. Data was collected from February 1, 2015 to February 7, 2015.

We received survey results back from 30 patients. We recorded daily weather parameters (temperature, absolute humidity, and barometric pressure) during evening time between 5 pm and 7 pm for Columbus Ohio from the National Weather Service website beginning on January 31, 2015 to February 8, 2015.

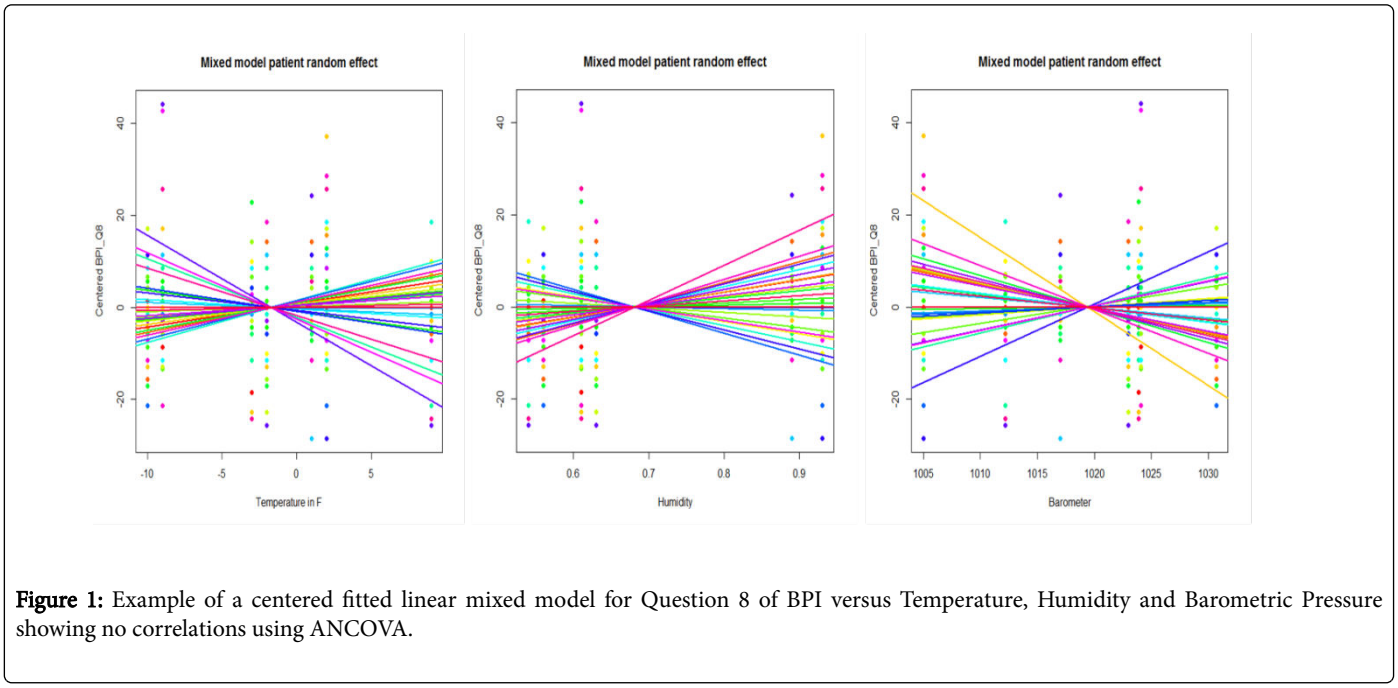

Figure 1: Example of a centered fitted linear mixed model for Question 8 of BPI versus Temperature, Humidity and Barometric Pressure showing no correlations using ANCOVA.

We received back a total of 210 FIQR and BPI forms (209 completed forms, 1 empty form). After the data was centered to remove the bias effect for each patient, linear correlations between weather parameters (temperature, humidity, and barometric pressure), FIQR, and BPI were done using Pearson correlation coefficient. Analysis of covariance (ANCOVA) was used to correlate each patient trend with the weather parameters following:

$y_i=\mu+\alpha_i+(\theta+\beta_i) \times W+e_i$ Equation 1.

where y_i was the questionnaire item for the i patient, μ was the grand mean or general intercept of the model, α_i was the random effect of the i patient on the intercept, θ was the general slope, β_i was the random effect of the i patient on the slope, W was the weather random variable factor (temperature (°C), barometric pressure (bar) and relative humidity (%)), and e_i was the error for the i patient distributed as a $N\sim(0, \sigma^2)$. Finally, principal component analysis (PCA) was used to recognize patterns in our data using the 209 forms and each individual question. The principal component (PC) scores of the samples were correlated with the three weather variables using Pearson simple linear correlation coefficient (Figure 1).

Results

We found no significant effect of weather parameters on fibromyalgia symptoms. Some FIQR and BPI questions had a positive Pearson correlation coefficient demonstrating a positive linear relationship while other questions had a negative correlation coefficient demonstrating a negative linear relationship towards the weather parameters. No consistent linear trend between the FIQR and BPI questions and the weather parameters was seen. None of the questions were associated with a strong linear relationship. The closer to +1 or -1 for the Pearson correlation coefficient, the stronger the association either positively or negatively. The most positive Pearson correlation coefficients for any of the FIQR and BPI questions and the weather parameters were 0.09, 0.23, and 0.27 for temperature, humidity, and pressure respectively while the most negative Pearson correlation coefficients were -0.13, -0.021, -0.19 respectively. ANCOVA did not show any correlation between the questionnaire items and weather parameters. Strong random subject effect was observed in the ANCOVA.

	Temperature (°C)	Relative Humidity (%)	Barometric Pressure (bar)
PC1 (28.8%)	0.02	0.02	-0.08
PC2 (6.6%)	-0.11	-0.12	0.26 ***
PC3 (5%)	0.04	-0.15 *	0.12
PC4 (4.8%)	-0.01	-0.02	0.02
PC5 (4.3%)	0.01	-0.09	0.01
PC6 (3.7%)	-0.05	0.01	-0.01
PC7 (3.4%)	0.09	-0.08	0.01
PC8 (3.2%)	0.04	0.07	-0.05
PC9 (3.15%)	-0.12	-0.05	0.11
PC10 (2.9%)	-0.09	-0.03	0.08

Table 1: Correlation coefficient. p-value: *<0.05, **< 0.01, ***<0.001; PC: Principal Component; (%)=variance explained for the PC/ Total variance of the data × 100.

PCA did not reveal any strong patterns in variability in our dataset. PCA is a statistical technique used to take a large dataset with many variables and make it more manageable by compressing it to bring out strong patterns in the dataset. We wanted to determine out of all the questions in the FIQR and BPI questionnaires answered by the subjects, if we could detect a strong pattern when comparing it to the weather parameters. The largest amount of variance is carried by the principal component 1 (PC1). The first principal component accounts for as much of the variability in the data as possible, and each succeeding principal component accounts for less and less remaining variability. Our first principal component accounted for only 28.8% of the variability in our data (Table 1), and we did not find any significance in the weather parameters. We found some significance in the barometric pressure in the 2nd principal component and in humidity in the 3rd principal component. However these accounted for only 6.6% and 5% of the variability in our dataset, which are too low to extract strong conclusions.

Discussion

This study revealed strong individual/patient random effect on the relation between questionnaire items and weather parameters. Analysis of covariance did not find any significant effect of weather on fibromyalgia symptoms. While in our principal component analysis, we found some significant linear correlations in the barometric pressure with PC2 and relative humidity with PC3. PC2 and PC3 accounted only for 6.6% and 5% of the total variance of the data, respectively. Higher number of participants and/or higher number of follow-up days would be required to verify our findings and consolidate the pattern in our dataset.

There have been several studies showing increased sensitivity in fibromyalgia patients to direct cooling or heating of the skin [20-24]. Lapossy et al. found significantly more frequency of cold induced vasospasm in fibromyalgia patients than in control using capillary video microscopy of the nail fold [20]. Berglund et al. found that fibromyalgia patients had lower perception threshold for cold pain, heat pain, cold-pain tolerance, and heat-pain tolerance compared to control using a Thermotest with two equally sized 50 × 25 mm contact thermodes [21]. Smith et al. found greater sensitivity to heat and cold pain stimuli compared to control doing quantitative sensory testing in the thenar area of the right hand using a 3 × 3 cm contact thermode [22]. Drummond and Wilcox found that clinical pain increased significantly with forehead cooling compared to control [23].

These studies are important in the debate of whether weather affects fibromyalgia symptoms as they do show increased sensitivity of fibromyalgia patients to direct skin temperature changes. We know that direct cooling or heating of the skin of fibromyalgia patients cause significant changes or pain compared to controls. However, several authors have pointed out that while the outdoor (recorded) temperature may be cold or hot, the indoor temperature may be quite different, where we presume most fibromyalgia patients spend the bulk of their time [1,6,16].

The difficulty in evaluating whether weather affects fibromyalgia symptoms, is that there are so many variables and biases such as how much patients spend time outdoors, how much clothes they are wearing, weather variations throughout the day, patients' perception of their pain, mood, etc. Ironically perhaps it may not even matter whether any study proves or disproves that weather has an effect on fibromyalgia symptoms as Donald C. Quick pointed out, "for patients who believe that weather can influence their pain, the causes may not be known but the effect is real." [1].

The current study may have had several limitations. It had a small number of participants. Patients were aware that the study was evaluating weather's effect on fibromyalgia symptoms, which may have

caused bias. We did not specify what time of the day the patients should fill out their questionnaires. This may have made a difference as the weather in Columbus Ohio can change from morning to afternoon to evening. The daily weather parameters were recorded for the evening time between 5 pm and 7 pm.

Conclusions

This study investigated whether weather parameters of temperature, humidity, and barometric pressure could affect fibromyalgia symptoms using FIQR and BPI to measure symptoms, which had not been done before. We did not find any statistically significant effect of weather on fibromyalgia symptoms as measured by FIQR and BPI. PCA of the FIQR and BPI showed low correlation with barometric pressure and humidity but they accounted for only 6.6% and 5% of the variability in our dataset, which are too low to extract strong conclusions from.

Availability of Data and Materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions

DK participated in recruitment of subjects, provided direct patient care and drafted manuscript. MP provided statistical analyses. DW participated in direct patient care and assisted in manuscript. KH participated in study conception, study design, recruitment of subjects, provided direct patient care and editing of manuscript. All authors read and approved the final manuscript.

Competing Interests

The authors declare that they have no competing interests

Ethics Approval and Consent to Participate

This study was approved by the Biomedical Sciences Institutional Review Board of The Ohio State University on 9/25/2014. Protocol number is 2014H0168. This approval is issued under The Ohio State University's OHRP Federal wide Assurance #00006378. Informed consent for the publication of this data was obtained from all participants.

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