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Original Research Article

Acute Low Back Pain? Do Not Blame the Weather—A Case-Crossover Study

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Abstract

Objective. To investigate the influence of various weather parameters on the risk of developing a low back pain (LBP) episode.

Design. Case-crossover study.

Setting. Primary care clinics in Sydney, Australia.

Subjects. 981 participants with a new episode of acute LBP.

Methods. Weather parameters were obtained from the Australian Bureau of Meteorology. Odds ratios (OR) and 95% confidence intervals (95% CI) were derived comparing two exposure variables in the case window—(1) the average of the weather variable for the day prior to pain onset and (2) the change in the weather variable from 2 days prior to 1 day prior to pain onset—with exposures in two control windows (1 week and 1 month before the case window).

Results. The weather parameters of precipitation, humidity, wind speed, wind gust, wind direction, and air pressure were not associated with the onset of acute LBP. For one of the four analyses, higher temperature slightly increased the odds of pain onset.

Conclusions. Common weather parameters that had been previously linked to musculoskeletal pain, such as precipitation, humidity, wind speed, wind gust, wind direction, and air pressure, do not increase the risk of onset for LBP.

Key Words. Low Back Pain; Weather; Meteorology; Case-Crossover Design; Epidemiology; Risk Factors

Introduction

Low back pain (LBP) is an expensive [1], major global health problem, with the majority of people experiencing LBP at some point in their life. This makes it the most prevalent musculoskeletal condition, affecting up to 33% of the world's population at any given time [2]. The causes of LBP are poorly understood, with a belief that different causal mechanisms occur at different stages in its development [3]. This poor understanding makes it difficult to diagnose the pathanatomical cause of the pain, leaving it often defined as non-specific LBP [4].

The perceived relationship between unfavorable weather (e.g., cold wet days) or changes in the weather and pain have been recorded since Roman times, with Hippocrates noting that many illnesses are related to changes in season [5]. Some people report that their pain symptoms are affected by the weather [6]. It is also believed that a variation in climate and weather is associated with a worsening of symptoms for several medical conditions, such as depression [7], rheumatoid arthritis [8], fibromyalgia [9], and LBP [10].

Despite the common belief that the weather can affect pain onset [11], few studies have investigated this association in relation to LBP. Existing studies have a few key limitations: they do not use a quantitative design, they have relied on participants' subjective recall of weather, and they have not blinded participants to the study hypothesis. One recent study [12] avoided all three of these limitations and concluded that many of the weather parameters examined, including temperature, precipitation, humidity, air pressure, and wind direction, had no link to the onset of LBP. Higher wind speed (odds ratio [OR] 1.17, 95% confidence interval [95% CI] 1.04 to 1.32, $P = 0.01$ for an increase of 11 km/h), and wind gust speed (OR [95% CI] 1.14 [1.02 to 1.28], $P = 0.02$ for an increase of 14 km/h) were the two exceptions, in which a small increase in risk was found, but these were deemed not clinically important [12]. These findings challenged previously held beliefs that adverse weather conditions increase the risk of developing LBP. Following publication of this study many people took to social media to express their disagreement with and criticism of the results [13,14]. The huge response to this study and the disbelief among the general population in its results provide a strong rationale to replicate the study in a new group of patients to determine whether the findings generalize.

The aim of this study was to examine the association between various weather parameters and risk of a new episode of LBP.

Methods

Study Design

This study used data from the PACE trial [15], a placebo-controlled trial that evaluated paracetamol (acetaminophen) for the treatment of acute LBP. Patients were recruited across 235 primary care centers in Sydney from November 11, 2009 to March 5, 2013. A case-crossover design was used to compare LBP onset with various weather parameters.

Ethics approval for the PACE trial was granted by the University of Sydney Human Research Ethics Committee. The use of the de-identified PACE data was approved by Macquarie University Human Research Ethics Committee.

Participants

The inclusion criteria for the PACE trial were as follows: a new episode of acute LBP between the 12th rib and buttock crease, with or without leg pain, for less than 6 weeks' duration, preceded by 1 month of no pain and of at least moderate intensity as measured by an adaptation of item 7 of the Short Form 36 Health Survey [15]. We included a subset of participants from the PACE study who had reported that the onset of pain was 7 days or less prior to their entry into PACE. This decision was made as accurate recall of the date of pain onset was important.

The exclusion criteria for the PACE trial were as follows: suspected serious spinal pathology, use of regular recommended doses of analgesics, spinal surgery in the preceding 6 months, use of psychotropic drugs for an uncontrolled mental health condition, or pregnancy or plans to become pregnant during the study period [15]. Patients were excluded from this study if their onset of pain was greater than 7 days or if we were unable to assign them to one of the three major Sydney weather regions owing to missing information.

Study Variables

A case-crossover design was used to compare exposure to weather parameters at the time of the participants' pain onset (case window) with exposure at the same time 1 week (7 days) and 1 month (28 days) prior (defined as the first and second control windows, respectively). The weather exposure variables used in the analyses for the case window were (1) the average of the weather variable for the day prior to pain onset and (2) the change in the weather variable from 2 days prior to 1 day prior to pain onset. We used a similar approach for the 1 week and 1 month control windows.

Pain data: Information on the date participants first experienced pain was collected by trained interviewers over the phone. Upon enrollment in PACE, participants were asked to list the number of days since their pain onset.

Meteorological data: Meteorological data were obtained from the Australian Bureau of Meteorology (www.bom.gov.au/) for the entire study period from 11 Sydney weather monitoring stations and then compiled into three major regions. The information was then collected from the station closest to where the patient resided, according to postal codes. The weather parameters of precipitation (mm/h), temperature (°C), relative humidity (%), wind speed (km/h), wind gust (km/h), wind direction (degrees true), and air pressure (hPa) were obtained.

Statistical Analysis

The characteristics of the study participants and distribution of weather parameters were analyzed based on standard methods for stratified analyses. A pair-matched analytic approach (conditional logistical regression) was used to contrast exposures (meteorological variables) for the case window with exposure to the control window [16,17]. As we used two control windows and two exposure variables to characterize each weather parameter, the effect of the weather parameters on risk of LBP onset was calculated in four different ways: (1) case versus first control window (7 days prior to case window) for the daily average of that weather parameter, (2) case versus first control window (7 days prior to case window) for the 24 h change in that weather parameter, (3) case versus second control window (28 days prior to case window) for the daily average of that weather parameter, (4) case versus second control window (28 days prior to case window) for the 24 h change in that weather parameter. The effect of each weather parameter was described using OR (95% CI). The analyses were performed using STATA version 12, with all weather parameters treated as continuous variables and the OR calculated for a one standard deviation (SD) increase in the weather parameter [18].

Results

Data on 981 individuals with acute LBP were included in the analysis. Table 1 shows the characteristics of the study participants. Participants included in the study had a mean age (SD) of 44.3 (15.0) years, were slightly more male (52.6%), and were mostly currently employed (76.9%). The mean (SD) days since onset of pain were 3.4 (2.1), with a mean (SD) of 6.9 (15.2) for the number of previous episodes and a mean (SD) of 6.5 (1.9) for pain intensity.

Throughout the study period the mean (SD) and range for the weather parameters were as follows: 1.3 mm (3.4) of precipitation (ranging from 0 to 45.7), 17.2 °C (4.9) of temperature (ranging from 5.4 to 32.8), 72.0% (12.3) humidity (ranging from 18.8 to 100), 11.8 km/h (7.4) wind speed (ranging from 1.5 to 48.1), 16.9 km/h (9.0) wind gust (ranging from 2.8 to 64.9), 167.2 degrees true (56.7) wind direction (ranging from 25.4 to 334.6) and 1017.6 hPa (6.6) of air pressure (ranging from 995.7 to 1,037.6) (Table 2).The descriptive data for the meteorological parameters are presented in Table 2.

The estimates of the weather parameters from the conditional logistic regression model are listed in Table 3.

Table 1 Baseline characteristics of participants*

Characteristic	Sydney Central (N = 500)	Sydney North West (N = 209)	Sydney South West (N = 272)	Overall (N = 981)
Age (years)	44.3 (15.1); N = 500	46.5 (14.8); N = 209	42.4 (14.7); N = 272	44.3 (15.0); N = 981
Gender (male)	257/498 (51.6%)	115/206 (55.8%)	141/271 (52.0%)	513/975 (52.6%)
Private health insurance	243/499 (48.7%)	119/208 (57.2%)	101/272 (37.1%)	463/979 (47.3%)
Income				
Negative of nil income	6/490 (1.2%)	5/198 (2.5%)	12/267 (4.5%)	23/955 (2.4%)
$1–$649 ($1–$33,799)	137/490 (28.0%)	47/198 (23.7%)	87/267 (32.6%)	271/955 (28.4%)
$650–$1,699 ($33,800–$88,399)	217/490 (44.3%)	89/198 (44.9%)	110/267 (41.2%)	416/955 (43.6%)
$1,700–$3,999 ($88,400–$207,999)	106/490 (21.6%)	47/198 (23.7%)	51/267 (19.1%)	204/955 (21.4%)
$4,000 or more ($208,000 or more)	24/490 (4.9%)	10/198 (5.1%)	7/267 (2.6%)	41/955 (4.3%)
Currently employed	391/500 (78.2%)	157/208 (75.5%)	206/272 (75.7%)	754/980 (76.9%)
Days since onset of pain†	3.4 (2.1); N = 500	3.4 (2.11); N = 209	3.3 (2.1); N = 272	3.4 (2.1); N = 981
Number of previous episodes	5.9 (12.1); N = 498	9.9 (18.82); N = 208	6.6 (17.0); N = 272	6.9 (15.2); N = 978
Pain extending beyond knee	77/499 (15.4%)	32/209 (15.3%)	57/270 (21.1%)	166/978 (17.0%)
Number of days of reduced activity‡	2.1 (2.2); N = 499	2.1 (2.36); N = 208	1.8 (2.1); N = 271	2.0 (2.2); N = 978
Disability (RMDQ)	13.3 (5.0); N = 500	13.3 (5.14); N = 209	13.6 (5.2); N = 272	13.4 (5.1); N = 981
Feelings of depression in last week	2.7 (2.9); N = 500	3.0 (3.0); N = 208	2.8 (2.9); N = 270	2.8 (2.9); N = 978
Perceived risk of persistent pain	4.1 (2.8); N = 500	4.7 (2.7); N = 208	4.2 (2.8); N = 270	4.2 (2.8); N = 978
Back pain episode compensable§	40/499 (8.0%)	9/208 (4.3%)	32/271 (11.8%)	81/978 (8.3%)
Currently using medications	183/499 (36.7%)	87/209 (41.6%)	99/271 (36.5%)	369/979 (37.7%)
Pain intensity	6.3 (1.9); N = 499	6.7 (1.9); N = 209	6.8 (1.9); N = 272	6.5 (1.9); N = 980
Global rating of change	0.1 (2.0); N = 498	−0.1 (2.1); N = 209	−0.2 (2.3); N = 271	−0.1 (2.1); N = 978
Sleep quality	2.5 (0.8); N = 499	2.5 (0.8); N = 209	2.5 (0.8); N = 271	2.5 (0.8); N = 979
Patient functional scale	3.5 (1.9); N = 499	3.3 (1.9); N = 209	3.3 (1.7); N = 271	3.4 (1.8); N = 979

*Data are mean (SD) or n/N (%). N: number of participants providing data.

†Days since onset of pain: number of days since onset of current episode of low back pain.

‡Number of days of reduced activity: number of days present episode forced a reduction in usual activity for more than half a day.

§Back pain episode compensable: patients claiming compensation for present episode.

RMDQ: Rolland Morris Disability Questionnaire.

Table 2 Features of weather parameters for study period (December 2009 to November 2012)

	Sydney Central			Sydney South West			Sydney North West		
Weather parameter	Mean (SD)*	Min	Max	Mean (SD)*	Min	Max	Mean (SD)*	Min	Max
Precipitation (mm/h)	1.4 (3.6)	0.0	45.4	1.1 (3.0)	0.0	33.2	1.4 (3.6)	0.0	45.7
Temperature (°C)	18.3 (4.3)	9.2	32.8	16.1 (4.9)	5.4	30.7	17.3 (5.1)	5.4	32.0
Relative humidity (%)	67.5 (12.6)	18.8	98.4	73.2 (10.4)	32.5	99.0	75.2 (12.4)	27.0	100.0
Wind speed (km/h)	20.1 (6.3)	8.6	48.1	7.4 (2.6)	1.6	19.8	8.0 (3.8)	1.5	27.4
Wind direction (degrees true)	192.2 (65.8)	27.9	334.6	143.9 (47.7)	25.4	313.8	165.5 (43.5)	30.4	306.7
Wind gust (km/h)	25.9 (8.2)	11.0	64.9	12.5 (4.6)	2.9	37.7	12.3 (5.6)	2.8	42.5
Air pressure (hPa)	1017.4 (6.5)	995.8	1037.3	1017.7 (6.6)	995.7	1037.6	1017.7 (6.6)	995.7	1037.6

*Data are mean (SD) of daily measures for study period. All values are based on averages of hourly measures over 24 h period.

From the 28 analyses performed, only one of the weather parameters provided a marginally significant association with the onset of LBP; higher temperature (OR [95% CI], 1.20 [1.01 to 1.42], $P = 0.03$ for an increase of 5 °C) increased the odds of pain onset.

Discussion

Statement of Principal Finding

This study evaluated the effect of weather on the risk of onset of LBP. Contrary to popular belief, the weather parameters of precipitation, air pressure, wind direction, wind speed, wind gust, and humidity were not associated with the onset of acute LBP. This finding was consistent whether we looked at weather on a single day or changes in the weather over time or varied the control window from 1 week prior or 1 month prior to the case window. Higher temperature signaled a slight increase in the risk of back pain that was marginally statistically significant for one of four analyses. If we had adjusted the *P* value for multiple comparisons, this *P* value would not have been statistically significant.

Strengths and Weaknesses

A major strength of this study was that data for weather and pain were collected independently of each other, and because the study was conceived after the data had been collected, the data were collected blind to the study hypotheses. We also used objective weather data from the Bureau of Meteorology. The case-crossover design controls for stable within-subject characteristics, as the person acts as his or her own control, which helps control for confounding [19]. Our study results were robust and uninfluenced by the use of two exposure variables for the case window or the sensitivity analyses using a second control window, apart from temperature, which was marginally significant for only one of the four analyses.

The study has some limitations. Recall is a potential limiting factor, given that some people may not accurately recall their exact day of pain onset. For this reason, we only included those patients with a pain onset of less than 7 days to minimize time recall bias. The weather data collected were based on each participant's home address, but it did not take into account whether they spent the majority of their day away from home. In addition, it did not factor in whether people spent the majority of their day inside, outside, or traveling, or whether they were exposed to air conditioning, heaters, or other external objects that could affect the weather they experienced. The temperate Sydney climate may be another factor to take into account, considering the temperature range is less than in many parts of the world. It is possible that results may differ in regions with more extreme weather conditions. Lastly, we studied a specific patient group, and our results may not generalize to those with chronic LBP or other long-term musculoskeletal conditions such as arthritis. We would encourage future research investigating those patient groups.

Comparison with Other Studies

The results of this study confirm the result of our earlier study, which found no influence of various weather conditions on the risk of LBP [12] in a separate group of participants. Similarly to the current study, that one was a case-crossover design that investigated weather exposures using various case and control windows in relation to pain onset. Both this study and our earlier study found no association between these weather parameters and the risk of onset of LBP. Each study independently recruited patients with acute LBP presenting for care. Besides our earlier study, there has been very little research investigating the effect of weather and the onset of LBP. The few other studies aimed at investigating this area were based on very weak designs, often only surveying patients about their opinions on the effect of weather.

Meaning of Study: Possible Explanations and Implications for Clinicians and Policymakers

This study provides evidence that common weather parameters, such as precipitation, temperature, air pressure, wind direction, wind speed, wind gust, and

Table 3 Effect of weather parameters on onset of acute low back pain

Weather parameters	Odds ratio (95%CI)	P	1 SD*
Precipitation (mm)			
Daily average (case versus control window1)†	1.08 (1.00 to 1.18)	0.062	3
24 h change (case versus control window 1)‡	0.98 (0.91 to 1.06)	0.678	3
Daily average (case versus control window 2)§	1.00 (0.94 to 1.07)	0.947	3
24 h change (case versus control window 2)**	1.01 (0.95 to 1.07)	0.770	3
Temperature (°C)			
Daily average (case versus control window1)†	1.08 (0.90 to 1.31)	0.413	5
24 h change (case versus control window 1)‡	1.02 (0.82 to 1.26)	0.880	5
Daily average (case versus control window 2)§	1.20 (1.01 to 1.42)	0.033	5
24 h change (case versus control window 2)**	0.98 (0.79 to 1.23)	0.889	5
Humidity (%)			
Daily average (case versus control window1)†	0.98 (0.89 to 1.07)	0.612	12
24 h change (case versus control window 1)‡	0.99 (0.90 to 1.10)	0.881	12
Daily average (case versus control window 2)§	0.99 (0.90 to 1.08)	0.744	12
24 h change (case versus control window 2)**	0.98 (0.89 to 1.09)	0.741	12
Wind speed (km/h)			
Daily average (case versus control window1)†	1.02 (0.89 to 1.17)	0.809	8
24 h change (case versus control window 1)‡	1.01 (0.89 to 1.16)	0.833	8
Daily average (case versus control window 2)§	1.01 (0.88 to 1.16)	0.877	8
24 h change (case versus control window 2)**	0.99 (0.87 to 1.14)	0.922	8
Wind direction (degrees true)			
Daily average (case versus control window1)†	0.97 (0.86 to 1.08)	0.556	60
24 h change (case versus control window 1)‡	0.95 (0.86 to 1.05)	0.322	60
Daily average (case versus control window 2)§	0.90 (0.81 to 1.00)	0.058	60
24 h change (case versus control window 2)**	0.92 (0.83 to 1.01)	0.091	60
Wind gust (km/h)			
Daily average (case versus control window1)†	1.01 (0.89 to 1.15)	0.848	10
24 h change (case versus control window 1)‡	1.00 (0.89 to 1.13)	0.960	10
Daily average (case versus control window 2)§	1.00 (0.88 to 1.13)	0.982	10
24 h change (case versus control window 2)**	0.98 (0.87 to 1.11)	0.741	10
Pressure (hPa)			
Daily average (case versus control window1)†	0.98 (0.91 to 1.07)	0.690	6
24 h change (case versus control window 1)‡	1.04 (0.93 to 1.18)	0.465	6
Daily average (case versus control window 2)§	1.01 (0.92 to 1.09)	0.895	6
24 h change (case versus control window 2)**	1.01 (0.89 to 1.14)	0.919	6

*Per 1-SD increase.
†Case versus control window 1 (7 days prior to case window) for daily average of that weather parameter.
‡Case versus control window 1 (7 days prior to case window) for 24 hour change in that weather parameter.
§Case versus control window 2 (28 days prior to case window) for daily average of that weather parameter.
**Case versus control window 2 (28 days prior to case window) for 24 h change in that weather parameter.

humidity, that are believed to be associated with musculoskeletal pain do not have an effect on the risk of onset of a new episode of LBP. There are a number of potential explanations for why people mistakenly believe that their pain is triggered by adverse weather. Humans are fallible and susceptible to so-called patternicity, where they see patterns in meaningless noise [20], and confirmation bias [21], where they preferentially recall events that confirm their pre-existing views and ignore or discount events that challenge that view. In an interesting study, Redelmeier and Tversky [22] demonstrated that rheumatoid arthritis patients tended to see patterns in their symptoms and the weather, though none existed, and that when college students were presented with graphical displays of arthritis pain and weather over time, they also saw patterns where none existed. The authors concluded that beliefs about pain and the weather "may tell more about the workings of the mind than of the body."

Unanswered Questions and Future Research

We studied a specific patient group of people with acute LBP. Our results may not generalize to those with chronic LBP or other long-term pre-existing musculoskeletal conditions, such as arthritis. We would encourage future research investigating those patient groups. The issue of where patients live and work also needs to be addressed, along with certain characteristics and exposures in their everyday lives, including time spent indoors or outdoors and exposure to air conditioning or heaters. Furthermore, future investigations in regions with more extreme climatic conditions than those in Sydney are suggested.

Conclusion

In conclusion, this study demonstrates that many weather parameters previously believed to influence musculoskeletal pain do not increase the risk of an episode of LBP. Higher temperature provided a slight increase in the risk of back pain for only one of the four analyses that were conducted, and although this reached statistical significance, the magnitude of the increase was not clinically important.

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