Effect of weather on temporal pain patterns in patients with temporomandibular disorders and migraine

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SUMMARY Patients with masticatory muscle pain and migraine typically report that the intensity of pain fluctuates over time and is affected by weather changes. Weather variables, such as ambient temperature and humidity, may vary significantly depending on whether the individual is outdoor or indoor. It is, therefore, important to assess these variables at the individual level using portable monitors, during everyday life. This study aimed to determine and compare the temporal patterns of pain in individuals affected with facial and head pain and to investigate its relation with weather changes. Eleven patients (27·3 ± 7·4 years) with chronic masticatory muscle pain (MP) and twenty (33·1 ± 8·7 years) with migraine headache (MH) were asked to report their current pain level on a visual analogue scale (VAS) every hour over fourteen consecutive days. The VAS scores were collected using portable data-loggers, which were also used to record temperature, atmospheric pressure and relative humidity. VAS scores varied markedly over time in both groups. Pain VAS scores fluctuate less in the MP group than in the MH group, but their mean, minimum and maximum values were higher than those of migraine patients (all $P < 0.05$). Pain scores <2 cm were more common in the MH than in the MP group ($P < 0.001$). Perceived intensity of pain was negatively associated with atmospheric pressure in the MP group and positively associated with temperature and atmospheric in the MH group.

Our results reveal that patients with masticatory muscle pain and patients with migraine present typical temporal pain patterns that are influenced in a different way by weather changes.

KEYWORDS: temporomandibular joint disorders, migraine disorders, facial pain, ecological momentary assessment, weather

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Introduction

Masticatory muscle pain is the most prevalent symptom reported by patients with temporomandibular disorders (TMDs). The aetiology of TMDs is still debated, and it is known to be multifactorial. Trauma, comorbid pain conditions, jaw parafunctions, as well as anatomic, psychosocial, genetic and neurobiological factors, may all contribute to their establishment (1). Migraine is a common headache disorder characterised by intense and debilitating headaches accompanied by visual or/and sensory symptoms and a prodromal phase. Although the aetiology of migraine is not completely understood, it is known to run in families and likely related to altered neurovascular mechanisms (2). Masticatory muscle pain and migraine can strongly affect the psychophysical and social domain, with a significant impact on patients' quality of life, as well as healthcare costs when they establish as chronic conditions (3, 4).

Subjects with masticatory muscle pain or migraine typically report fluctuations of pain levels over time (5, 6). Masticatory muscle pain mainly affects jaw-closing muscles and often results in masticatory dysfunction (7, 8). Pain is regional, it can be unilateral or bilateral, and is typically perceived around the ear, the angle/body of the mandible and the temporal region. Referral patterns include intra-oral and extra-oral areas. Pain has been qualitatively described to be dull, heavy or aching.

Migraine is a recurrent headache disorder manifesting as pain attacks lasting 4–72 h. Typical characteristics of the head pain are unilateral location, pulsating quality, moderate or severe intensity, aggravation by routine physical activity and association with nausea, photophobia and phonophobia. Individuals affected with migraine report episodes of high-intensity pain alternated to pain-free periods (9, 10). Although a set of clear diagnostic criteria is available for both disturbances (8, 11), the clinical assessment of patients with masticatory muscle pain and migraine is often challenging due to common overlapping symptoms and to highly frequent comorbidity (12). As pain symptoms are often reported in similar locations, a differential diagnosis frequently relies on the evaluation of the pain course over time (12). Temporal pain patterns can be evaluated using paper-based diaries or ecological (or electronical) momentary assessment (EMA), an electronic data collection method which permits the participants to report on symptoms close in time (13), thus providing more accurate estimates. Indeed, data are gathered in real time, thus avoiding recall bias and retrospective assessments, which can often occur with a paper-based data collection method (13).

The pain course of subjects suffering from migraine is influenced by weather conditions (14, 15). Possible mechanisms underlying such relationship have been investigated in animal models, where changes in atmospheric pressure and temperature were found to be linked to peripheral vasoconstriction, a local increase in algesic substances and adrenaline with a general decrease in central and peripheral sensory pain thresholds (16). Yet, the possible effects of weather changes on masticatory muscle pain were investigated in a limited number of patients so far (17).

The objectives of this study were (i) to analyse the temporal pain pattern of facial pain in individuals suffering from masticatory muscle pain and migraine using EMA and (ii) to investigate whether and how climate changes affect pain symptoms in these individuals.

A comparison between the temporal profiles of these two conditions may be helpful for clinicians to facilitate a differential diagnosis in the clinical setting. It was hypothesised that migraine and masticatory muscle myalgia present a condition-specific temporal pain profile, and that climate changes influence pain self-reports.

Material and methods

Consecutive individuals seeking for a consultation at the Section of Temporomandibular Disorders at the University of Naples Federico II, Italy, were screened.

Patients suffering from masticatory muscle pain (DC I – diagnostic criteria for temporomandibular disorders – DC/TMD) (8) or migraine according to IHS (International Headache Society) criteria (11) for at least 6 months were invited to participate in the study. Pregnancy, systemic diseases affecting pain perception and a concurrent diagnosis of TMD and migraine were considered as exclusion criteria.

Each participant was provided with a custom-made portable data logger* to collect pain self-reports and weather variables. The device was set up to record ambient temperature (T, °C), atmospheric pressure (P, hPa) and relative humidity (RH%) every 15 min. It emitted a beep sound every hour from 8·00 am to 8·00 pm as reminder for surveying the pain. Participants were asked to score the intensity of their current pain using a 10 cm electronic visual analogue scale (VAS) built-in the portable device (left endpoint – no pain; right endpoint – worst pain I can imagine) and confirm their rating by pushing together two buttons located on the left and right side of the device. All participants were asked to use the device for at least two consecutive weeks. Subjects were asked to use painkillers only if strictly necessary and to note in a diary the intake of medications. Each patient was trained for the correct use of the device. All patients signed an informed consent. The protocol was reviewed by the local ethics committee.

The accuracy of the weather sensors was verified by cross-correlating the data collected by the portable device with those collected by a professional

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*Meteopain 2.0; STeBI Srl, Aversa, Italy.

meteorological station (University of Naples 'Parthenope') used as reference standard. The data logger was left close to the gold standard local forecast station for 2 weeks (17).

Statistical analysis

Visual analogue scale scores were described using means, standard deviations (SD), ranges, coefficients of variation (CV), relative frequencies of pain ratings where VAS scores were less than 2 cm (% low) and mean values of pain ratings where VAS scores was greater than 2 cm (meanHVAS). Comparisons between groups were performed using parametric and nonparametric tests, as appropriate. A mixed model was used to test for a possible relationship between VAS ratings and weather variables, by entering VAS pain scores as dependent variable, and temperature, pressure and humidity as covariates. Data were analyzed using SAS version 9.2 (SAS Institute, Cary, NC, USA).

Results

Four patients (three in the MP and one in the MH group) were excluded from the analysis for technical problems during recordings (two data-loggers stopped to emit the beep and two had battery problems during the recordings). Six subjects (three in the MP and three in the MH group) were further excluded because they had over 25% of missing VAS expected observations, and were considered non-compliant. The final sample included 31 patients, 11 (one man, 10 women; mean age 27·3 ± 7·4 years) with TMD/DC I diagnosis (MP) and 20 (three men, 17 women; mean age 33·1 ± 8·7 years) suffering from migraine (MH). During the observation period, nine MH subjects had one attack, three had two migraine attacks, six had three, and two had four episodes.

Descriptive statistics for VAS ratings and meteorological variables for both MP and MH groups are reported in Table 1. Examples of facial pain temporal profiles of two subjects from MP and MH groups are given in Fig. 1.

Between-groups differences in VAS ratings are reported in Table 2. MinVAS, maxVAS and meanVAS were significantly greater in the MP than the MH group ($P \leq 0.002$). CV and % lowVAS were significantly greater in MH than in MP patients (all $P \leq 0.002$). MeanHVAS was greater in MP than in MH individuals

Table 1. Descriptive statistics for pain VAS scores and weather variables – temperature (T, °C), relative humidity (RH, %) and atmospheric pressure (p, hPa) – during the study period

Group	Variable	Mean	SD	Minimum	Maximum
MP	VAS	4·3	2·3	0·0	9·6
	T	20·0	2·8	8·1	31·3
	RH	53·6	9·0	27·3	80·0
	p	1005·8	9·2	955·4	1032·2
MH	VAS	1·0	1·6	0·0	9·8
	T	20·2	3·2	11·1	36·9
	RH	55·5	9·3	21·4	78·0
	p	1008·8	13·5	920·6	1030·1

($P = 0.008$). The overall consumption of medication was very low during the study time, and the proportion of medication intake was similar between groups.

Results from the mixed model are reported in Table 3. A significant negative association was found between pain VAS and atmospheric pressure (p) in the MP group ($P = 0.025$). Positive significant associations were found between pain VAS and temperature (T) ($P = 0.001$), and between pain VAS and atmospheric pressure (p) ($P = 0.027$) in the MH group. VAS pain was not associated with relative humidity in both pain groups.

Discussion

EMA methodology was used to monitor the temporal pain pattern in individuals suffering from masticatory muscle pain or migraine and to evaluate the possible influence of weather changes on perceived levels of pain. The more rigorous prospective methodology of EMA (13) allowed collecting pain self-reports and meteorological variables continuously in everyday life settings. As far as we know, this is the first study which compares the temporal profile of pain in patients with TMD and migraine using EMA methodology.

The results show that masticatory muscle pain and migraine pain have distinct temporal profiles and that changes in environmental pressure and temperature affect individual pain response.

Our data show that the average pain intensity of MP individuals was 4·4 ± 1·8 cm and that pain peaked at 7·6 ± 1·1 cm. Also, the computed coefficient of variation (0·53), that is the ratio between the standard deviation and the mean, suggests that the variability of pain reports was rather low in these patients. Finally, the relative frequency of VAS scores
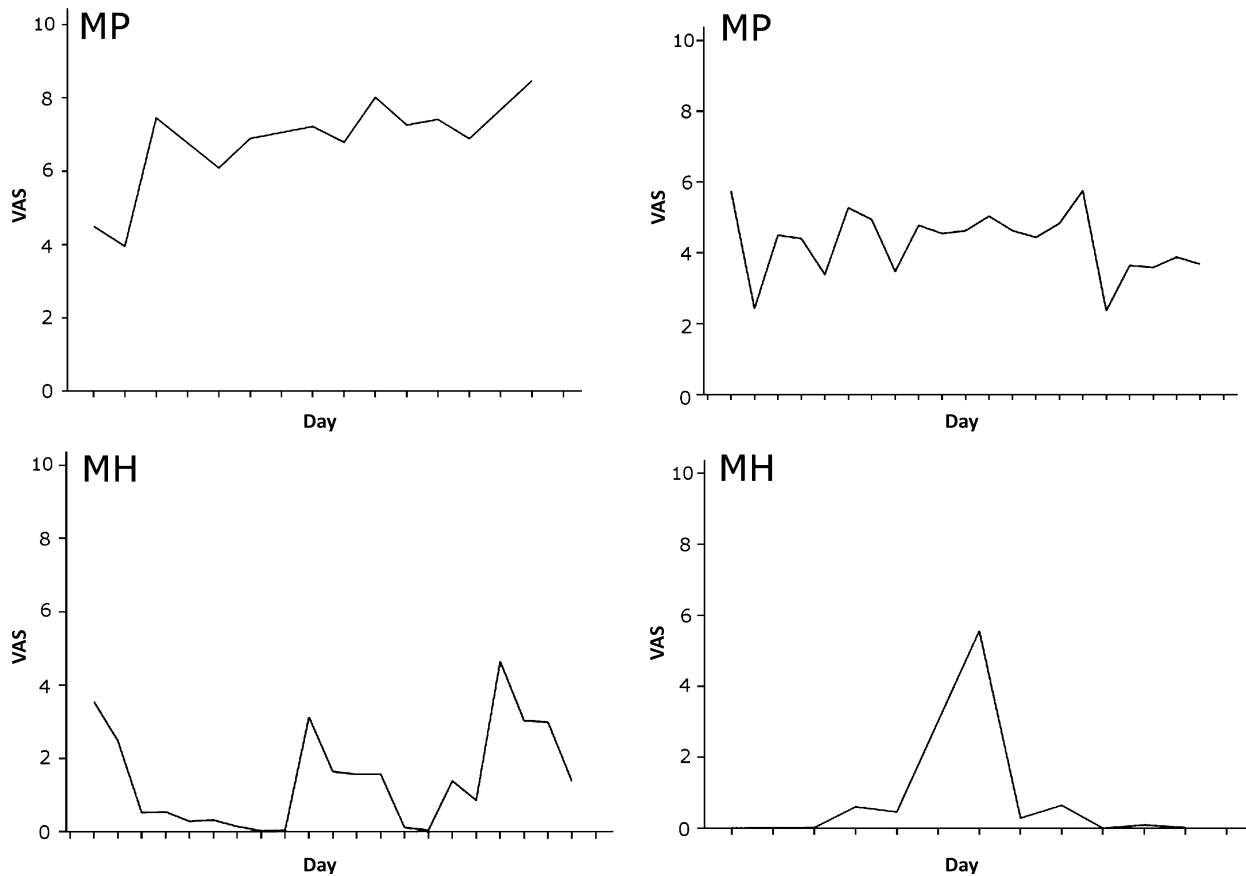
Fig. 1. Pain temporal profile (VAS scores) retrieved by sample individuals suffering from myofascial pain (MP) and migraine (MH). Note the on–off pain patterns (pain alternates with pain-free periods) of the MH patients and the continuous and fluctuating pain patterns of MP patients.

Table 2. Comparisons between VAS scores of MP and MH patients

	MP		MH		
	Mean	SD	Mean	SD	*P* value
minVAS	1·7	1·3	0·1	0·3	**0·002**
maxVAS	7·6	1·1	5·3	2·5	**0·002**
meanVAS	4·4	1·8	1·2	1·1	**<0·001**
stdVAS	1·4	0·3	1·4	0·8	0·990
CV	0·5	0·7	1·9	1·2	**0·002**
% lowVAS	14%	29%	73%	28%	**<0·001**
meanhVAS	4·9	0·9	3·7	1·2	**0·008**

Bold type: statistically significant.

Table 3. Association between pain VAS scores and meteorological data

Group	Effect	Regression coefficient	Standard error	*P* value
MP	T	0·024	0·024	0·320
	RH	−0·008	0·010	0·418
	p	−0·026	0·011	**0·025**
MH	T	0·058	0·018	**0·001**
	RH	0·007	0·006	0·257
	p	0·011	0·005	**0·027**

Bold type: statistically significant. T = ambient temperature; RH = relative humidity; p = atmospheric pressure.

less than 2 cm (% lowVAS) amounted only to 14% of the total pain reports. All these data support previous reports suggesting that masticatory muscle pain is characterised by moderate pain intensity, and to be continuous over time (5, 6), with short-lasting pain-free periods. The low frequency of VAS scores <2 cm (% lowVAS) also suggests that pain is most of the time clinically relevant in these individuals.

On the other hand, patients with migraine had a greater frequency of VAS scores <2 cm (% lowVAS), amounting to up to three-quarters of the total pain

reports. Additionally, the CV amounted to 1·88, suggesting that the variability in pain reports was relatively high. These data confirm that individuals affected with migraine alternate pain-free periods to episodes of high-intensity pain (12).

It was also found that the minVAS, the maxVAS, the meanVAS and the meanHVas were higher in MP than MH individuals. The observation that the average pain intensity (meanVAS) found in the MP group was higher than that of the MH group can be explained by the higher frequency of episodes with intensity <2 cm (%lowVAS) found in the latter group. Interestingly, if these episodes are excluded from the analysis, the MP patients had only slightly higher pain intensity than the MH patients. Although statistically significant, this difference is likely to be considered not clinically relevant. This also applies while considering the minVAS. On the other hand, the difference between groups in maxVAS, other than being statistically significant, is of some clinical significance (18). Hence, it appears that the patients with masticatory muscle pain experienced pain peaks of greater intensity than MH individuals. This difference might be explained in some ways. One hypothesis is that TMD muscular pain is more painful than migraine attacks. This observation however is in contrast to what Kelman *et al.* (19) reported, that is migraine related pain peaks up to 10 of 10 in numeric scales, and to common patients' reports suggesting that migraine attacks are among the worst painful experiences. It could also be argued that MH individuals took more frequently painkillers. But, the frequencies of drug intake were not different between groups. A third explanation for this unexpected finding has to be related to the subjectivity of VAS pain ratings. Indeed, pain reports might be influenced by an emotional component. It might be speculated that a greater intensity of pain peaks in MP subjects could be related to the psychological traits of these patients. Current evidence suggests that TMD pain is associated with depression (20), and that the latter is correlated with greater pain estimates (21) and somatisation (22). However, depression is highly frequent also in people with migraine (23). Hence, depression and somatisation are likely not to explain this finding. Another possibility is that the greater intensity of maximum pain of MP as compared to MH individuals might be partly explained by different pain coping strategies. It is known that both prediction and acceptance of pain

are associated with fewer pain reports (24). Migraine individuals are often aware of the temporal pattern of their pathological condition. In most cases, they can predict their painful attack and prevent the negative experience by acting familial behaviours able to reduce their pain. It is possible that such anticipatory behaviours might have accounted for reduced peak pain reports in MH individuals. This is unlikely to have occurred in individuals suffering from masticatory muscle pain. Finally, the difference between groups in VAS ratings might also be explained by the different pathophysiologic mechanisms related to peripheral and central nociception, and pain modulation.

The results of the current study also reveal a relation between the intensity of pain self-reports and weather variables. The presence of a putative relationship between weather variables and pain has been already investigated on a biological basis (16, 25). It was found that a low-pressure environment worsens pain by promoting the sympathetic activity, which in turn causes local vasoconstriction and ischaemia (25). Low-temperature increases pain through still unclear mechanisms, which include an increase in blood pressure, heart rate and noradrenaline levels (16). A cold environment may also favour the release of peripheral mediators, thus inducing vasoconstriction, local ischaemia and promoting the release of algesic substances by non-neuronal cells (16).

In this study, we found that a decrease in atmospheric pressure corresponded to an increase in VAS pain ratings in MP group. It has been shown that a drop in barometric pressure activates sympathetic nerves and promotes vasoconstriction (25). Reduced blood flow within the masseter affects negatively its metabolism (26) and favours the development of muscular fatigue and pain during sustained jaw muscle contraction (27), which is likely to be very frequent in individuals with TMD (28).

The analysis failed to find an effect of temperature on masticatory muscle pain reports. In an experimental setting, Sato *et al.* found that injections of hot (48 degrees) isotonic saline into the masseter where not able to determine a significant muscle pain, while hot solutions (48 degrees) of glutamate were able to increase participants pain reports as compared to cold and neutral solutions (29). After the injection, the local temperature increase was about 6 degrees in 10 s. These findings suggest that large and immediate

temperature changes within the masseter muscle can affect pain sensitivity. It is possible that in the current study, the variation of environmental temperature was not immediate and was not detected by muscular nociceptors because of other mechanisms that could have occurred to reduce the local temperature (e.g. sweating).

We also found that an increase in temperature and atmospheric pressure corresponded to increased pain ratings in MH patients. Migraineurs are more sensitive to various environmental stimuli than individuals without migraine. However, only in some migraineurs a significant weather sensitivity could be observed (15). Recently, Scheidt *et al.* (30) reported that both increases and decreases in temperature led to an increase of migraine attack reports. Zebenholzer *et al.* (15) reported that high pressure increased the risk of getting headache reports. Nonetheless, most of the medical literature regarding migraine triggers consists of studies performed using patient interviews and surveys, and it is often subjected to recall and selection bias that makes difficult further comparisons. The high variability of findings, probably due to the differences in study sample and study designs, makes it difficult to draw any consistent conclusion.

We found a positive association between migraine pain levels and atmospheric pressure. This is contrary to our expectation as anecdotal observations indicate that the low atmospheric pressure associated with high altitude may trigger migraine symptoms. However, a previous study suggested that high-altitude headache might be caused by hypoxia rather than low atmospheric pressure (31, 32). In our MH sample, the atmospheric pressure ranged from 920·6 to 1030·1 hPa, and it ranged from 955·4 to 1032·2 hPa in the MP group. According to the hypsometric curves, these values correspond to altitudes up to 800 m above sea level (920·6 hPA). The concentration of oxygen at this altitude levels is only minimally affected. It is therefore likely that other mechanisms may account to explain the positive relationship between pain scores and atmospheric pressure. For instance, good weather related to high atmospheric pressure may have positively affected mood (33), thus contributing to alleviate pain (34).

This study has some limitations. First, it included a small number of participants and the allocation to study groups was not stratified by gender. However,

the limited number of male individuals (1/11 in the MH group, and 3/20 in the MP group) has likely not affected the results. Second, the dropout rate was greater in MP than in MH group. However, as the devices were randomly assigned to participants, it is likely that the greater incidence of technical problems in the MP group may have occurred by chance. Third, the current study did not account for psychological personality traits that might be responsible for interindividual differences in pain ratings. Fourth, it did not analyse other environmental factors that may trigger migraine attacks. Finally, as the study was conducted in a Dental Clinic, it may be possible that the population of migraineurs investigated could have had a less severe pain complaint and impairment than other patients referred to specialty clinics.

In conclusion, the present study suggests that chronic masticatory muscle pain and migraine present typical time-related profiles that can be influenced by climate changes. Further studies are needed to test the pathophysiological mechanisms responsible for the relation between facial pain, due to temporomandibular disorders or migraine, and climate changes.

Acknowledgments

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