

Assessment of sleep quality in patients with orofacial pain and headache complaints: A polysomnographic study

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Abstract

Background. Sleep is a physiological function essential for survival, recovery, tissue repair, memory consolidation, and brain function. Pain is also an indispensable aspect of human life. The coexistence of sleep disorders and pain is often described in the literature, yet it is critical to define sleep not only subjectively but also using objective instrumental methods, such as polysomnography, that provide data on sleep quality.

Objectives. The aim of the study was to determine the relationship between orofacial pain (OFP), headache (HA) and sleep quality using subjective and objective sleep quality assessment methods. Additionally, we aimed to explore whether poor sleep quality was related to OFP and HA alone or was influenced by the coexistence of psycho-emotional factors such as depression, anxiety and stress.

Material and methods. A single-night video-polysomnography was performed on patients from the Outpatient Clinic for Temporomandibular Disorders at Wrocław Medical University, Poland, who had been diagnosed with OFP and HA. Additionally, questionnaires were employed to assess sleep quality, pain, HA, and the psycho-emotional state.

Results. There was no statistically significant relationship between the severity of OFP and HA and polysomnographic sleep quality parameters. On the other hand, the quality of sleep as determined by questionnaire studies correlated markedly with the severity of experienced pain. The severity of pain was found to be significantly correlated with depression, anxiety and perceived stress scores.

Conclusions. The psycho-emotional aspects are of critical importance in the perception of OFP and HA. They can be associated with worsened subjective sleep quality, insomnia or daytime sleepiness. Therefore, the treatment of such patients must be preceded by a comprehensive assessment of their psycho-emotional state, as anxiety, stress and depression can significantly influence the course of the disease and the response to treatment procedures.

Keywords: sleep quality, polysomnography, headache, orofacial pain, psycho-emotional state

Introduction

Sleep is a physiological function essential for recovery from fatigue, tissue repair, memory consolidation, and brain function.¹ It is an active neurobehavioral state that is maintained through a highly organized interaction of neurons and neural circuits in the central nervous system (CNS).¹ Pain is an indispensable part of human life, acting as a physical and emotional signal of body damage that strongly motivates human behavior.¹ Orofacial pain (OFP) encompasses a heterogeneous group of conditions, including dental, mucosal, musculoskeletal, neurovascular, and neuropathic pain,¹ and can be classified in terms of acuity and chronicity. However, the definition of chronic pain, which is pain that persists for more than 3 months, is not useful for assessing OFP and headache (HA) for chronicity.^{2–4} In OFP and HA, chronic pain is defined as pain that occurs more than 15 days per month and lasts more than 4 hours daily for at least the preceding 3 months.²

Disorders of systems regulating pain and sleep can have a broad negative impact on health and well-being. Sleep complaints are present in 67–88% of individuals suffering from chronic pain disorders.^{5–7} Moreover, at least 50% of those with insomnia, the most commonly diagnosed sleep disorder, suffer from chronic pain.^{8,9} Several studies that described a strong correlation between pain occurrence and decreased sleep quality also highlighted the crucial role of the psycho-emotional state of patients, including depression, somatization and anxiety.^{10–15} A number of studies investigating the relationship between OFP (especially pain associated with temporomandibular disorders (TMD)) and HA and the deterioration of sleep quality demonstrated an association between sleep disturbances and mood swings, impaired memory and cognition, changes in the immune system, and somatic pain complaints.^{1,2,9,16}

Previous studies have indicated the existence of a two-way relationship between pain and sleep quality. Sleep disorders can impair regenerative physiological processes and functions that support homeostasis. These disorders contribute to the development and persistence of chronic pain and poorer patient response to treatment, which makes pain management more difficult.^{17,18} Other studies have shown that pain can negatively affect sleep via cortical arousal mechanisms that interfere with falling asleep and maintaining sleep.¹⁹ In contrast with acute pain, in which the relationship is linear and rapidly reversible, chronic pain has been described as a vicious cycle with mutual deleterious influences between disturbed sleep and pain.²⁰ Many authors have also considered the possibility that the pain itself does not cause sleep quality deterioration in patients with OFP but rather psycho-emotional disturbance, such as high levels of stress, anxiety and depression, which are very common in patients suffering from pain.

The psycho-emotional state is a vital factor in the deterioration of sleep quality.^{21,22} However, the majority of existing research used subjective sleep quality indicators, such as questionnaires, which inadequately assess sleep quality. Polysomnography is a reliable and objective method for evaluating sleep quality. The objective of this study was to assess the relationship between pain, HA and sleep quality through the use of both subjective and objective assessment methods. All patients underwent a single-night video-polysomnography, and the data was compared to the results of sleep quality questionnaires. The study also aimed to explore whether low sleep quality was solely related to pain and HA, or whether it was influenced by the coexistence of psycho-emotional factors such as depression, anxiety and stress.

Material and methods

Participants

The study participants were patients of the Outpatient Clinic for Temporomandibular Disorders at Wrocław Medical University in Poland. Patients who reported OFP and/or HA and/or impaired sleep quality were referred for a single-night video-polysomnography at the Clinic of Internal Medicine, Occupational Diseases, Hypertension and Clinical Oncology at Wrocław Medical University, where, in addition to undergoing a polysomnographic examination, they completed several questionnaires related to their psycho-emotional state, sleep quality and pain. The study group consisted of patients who reported primary HA and OFP. Primary HA was defined as pain occurring in temporal relationship to the onset of pain, with no underlying pathological process, disease or traumatic injury. This included migraine, tension-type HA and trigeminal autonomic cephalalgias.³ Orofacial pain encompasses myofascial OFP (pain localized to the masticatory muscles, with or without functional impairment), temporomandibular joint (TMJ) pain (pain localized to the TMJ, occurring at rest or during jaw movement or palpation) and OFP that resembles presentations of primary HA (pain in the orofacial area resembling one of the primary HA types in pain character, duration and intensity, with or without the associated symptoms of these HA types but without concomitant HA).⁴ The study protocol was approved by the Ethical Committee of Wrocław Medical University (approval No. KB-794/2019). All study participants were informed of the purpose of the study and consented to participate. The study was conducted in accordance with the Declaration of Helsinki for research involving human subjects. The study was registered in the ClinicalTrials.gov database (identifier No. NCT04214561).

Inclusion criteria

The study included individuals over the age of 18 who reported OFP and/or HA and/or impaired quality of sleep and who were willing to participate.

Exclusion criteria

The main exclusion criteria were addiction to a drug or medication, the use of medicines that significantly affect the function of the nervous and muscular systems, severe systemic diseases, severe mental disorders, including significant mental disabilities, less than 4 hours of sleep recorded using polysomnography, and lack of consent to participate. Pregnant women, patients with a diagnosed sleep apnea disorder and those using a mandibular advancement device (MAD) or continuous positive airway pressure (CPAP) were excluded from the study.

Video-polysomnography procedure

The patients underwent a single-night video-polysomnography examination in the Sleep Laboratory at Wrocław Medical University using a Nox A1s™ (Nox Medical, Reykjavik, Iceland) device. The recording was performed between 10.00 pm and 6.00 am, taking into account the patient's individual preferences and sleeping habits. The polysomnographic examinations included electroencephalography, electrocardiography, electro-oculography, and electromyography recordings from the chin area and bilaterally from the regions of the masseter muscles, motion recording of abdominal and thoracic breathing activity, assessment of body position, and audio and video recording. A pulse oximeter (NONIN 3150 WristOx 2; Nonin Medical Inc., Plymouth, USA) was used to record oxygen saturation and pulse, while Noxturnal™ software (Nox Medical), developed for sleep recording and analysis, facilitated data analysis.

Pain assessment

McGill Pain Questionnaire

The McGill Pain Questionnaire (MPQ) contains 78 words that describe the experience of pain and provides scores that range from 0 (no pain) to 78 (severe pain). Results are considered clinically significant when the total value is greater than 5.²¹ A study by Melzack and Katz assessing the multidimensional nature of pain experience demonstrated that the short-form MPQ (SF-MPQ) is a reliable, valid and consistent measurement tool. The SF-MPQ is suitable for use in specific research settings where the time available to obtain information from patients is limited and where the aim is to obtain information that extends beyond the measurement of pain intensity.^{23,24}

Graded Chronic Pain Scale

The Graded Chronic Pain Scale (GCPS) allows for the grading of chronic pain severity, disability score and disability points. The following classifications are provided: Grade 0 – no pain in the previous 6 months; Grade I – low-intensity characteristic pain intensity <50, low disability, with <3 disability points; Grade II – high-intensity characteristic pain intensity ≥50, low disability, with <3 disability points; Grade III – moderately limiting high disability score of 3 to 4 disability points (regardless of characteristic pain intensity); and Grade IV – a severely limiting high disability score of 5 to 6 disability points (regardless of characteristic pain intensity).²⁵ Sharma et al. reported that the reliability of the one-month GCPS is equal to or better than the six-month version in terms of pain intensity, days of disability, pain interference, chronic pain grade, and high-impact pain.²⁶ The study demonstrated that the GCPS is a reliable and valid tool for measuring pain intensity and pain interference.²⁶

Headache Impact Test-6

The Headache Impact Test-6 (HIT-6) score ranges from 36 to 78, with a score ≤49 indicating no or little impact of HA on daily activities, 50–55 indicating a slight impact, 56–59 a significant impact, and ≥60 a severe impact. A study demonstrated that the HIT-6 is a reliable and valid instrument for measuring the impact of HA on daily life in both episodic and chronic migraine sufferers. The internal consistency reliability among migraine sufferers was high, ranging between 0.82 and 0.90.²⁷

Migraine Disability Assessment

The Migraine Disability Assessment (MIDAS) involves the summation of the total number of days indicated in questions 1–5. The grading system includes the following: Grade I – little or no disability over 0–5 days; Grade II – mild disability across 6–10 days; Grade III – moderate disability over 11–20 days; and Grade IV – severe disability for more than 21 days.²⁷ Stewart et al. demonstrated moderately high test-retest reliability of the MIDAS score for HA sufferers and a correlation with clinical judgment on the need for medical care.²⁸ The MIDAS score is calculated by summing the number of days missed from work or school, days missed from household chores, days spent on non-work activities, and days spent at work or school, as well as days spent on household chores where productivity was reduced by at least 50% over the previous 3 months. The correlation between the MIDAS summary score and an equivalent daily diary score was 0.63, while the group estimate of the MIDAS score was found to be a valid estimate of a rigorous diary-based measure of disability. In addition, the mean and median values for the MIDAS score in a population-based sample of migraine cases were comparable to those of equivalent diary measures.²⁸

Temporomandibular disorder pain screener

Individuals with a score of 3 or above on the TMD pain screener (range 0–7) are predicted to have painful TMD based on the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) and are, therefore, considered to have a positive TMD pain test result. The TMD pain screener demonstrated excellent sensitivity and specificity levels, as well as validity in correctly identifying participants with pain-related TMD (sensitivity of 99%) and healthy controls (specificity of 97%). The short screener correctly identified individuals with symptoms of competing conditions, including non-painful TMJ disorder (specificity of 95%) and HA not related to TMD (specificity of 96%).²⁹

Subjective assessment of sleep quality

Insomnia Severity Index

The Insomnia Severity Index (ISI) has a minimal score of 0 and a maximal score of 28. A value of up to 10 is considered within the normal range, while a score of 8–14 indicates sub-threshold insomnia. A score of 15–21 indicates significant moderate insomnia, while a score of 22–28 is indicative of severe insomnia.³⁰

Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI) is a tool designed to assess sleep quality over a one-month interval. The measure is comprised of 19 individual items, divided into 7 components of sleep quality, which collectively yield a single global score, ranging from 0 to 21. A lower score indicates better sleep quality. A total score of 5 is considered a designated cut-off point for poor sleep quality.³¹

Epworth Sleepiness Scale

The Epworth Sleepiness Scale (ESS) is a validated eight-item questionnaire that is used to assess subjective sleepiness. The ESS values range from 0 (unlikely to fall asleep in any situation) to 24 (high chance of falling asleep in all 8 situations). The final ESS score indicates normal sleepiness (1–10), mild daytime sleepiness (11–14), average daytime sleepiness (15–18), or severe daytime sleepiness (>18).³²

Psycho-emotional state assessment

Sense of Stress Questionnaire

The Sense of Stress Questionnaire (KPS) is designed to assess the structure of stress sensations. The questionnaire comprises 27 statements that can be used to calculate an overall score of an individual's generalized stress

level. In addition, 3 results related to emotional tension, intrapsychic stress (resulting from a confrontation with oneself) and external stress (resulting from the confrontation of the individual with the burdens perceived in the social and external worlds) are generated. The questionnaire also contains the scale of lies.³³

Perceived Stress Scale-10

The Perceived Stress Scale-10 (PSS-10) results range from 0 to 40. Scores between 0 and 13 are indicative of low stress, scores between 14 and 26 indicate moderate stress, and scores between 27 and 40 are indicative of high perceived stress.³⁴

Patient Health Questionnaire-9

Subjects rate the Patient Health Questionnaire-9 (PHQ-9) responses on a scale of 0 to 3 based on the frequency with which a given symptom has manifested in the last 2 weeks. Total scores for the 9 items range from 0 to 27, with a score of 10 or above indicating a high risk of a depressive episode. The higher the score, the greater the risk of depression. Scores are interpreted as follows: no depression (<5); mild depression (5–9); moderate depression (10–14); moderately severe depression (15–19); or severe depression (20).³⁵

Beck Depression Inventory

The Beck Depression Inventory (BDI) is a 21-item self-rated scale that evaluates key symptoms of depression, including mood, pessimism, sense of failure, self-dissatisfaction, guilt, punishment, self-loathing, self-accusation, suicidal ideation, crying, irritability, social withdrawal, indecisiveness, body image change, work difficulty, insomnia, fatigability, loss of appetite, weight loss, somatic preoccupation, and loss of libido. A total score of 0–13 is considered within the minimal range, while 14–19 is indicative of mild depression, 20–28 of moderate depression, and 29–63 of severe depression.³⁶

Beck Anxiety Inventory

The Beck Anxiety Inventory (BAI) score is calculated by summing 21 items and can range between 0 and 63 points. A total score of 0–7 is interpreted as minimal anxiety, 8–15 as mild anxiety, 16–25 as moderate anxiety, and 26–63 as severe anxiety.^{37,38}

Generalized Anxiety Disorder-7

The Generalized Anxiety Disorder-7 (GAD-7) questionnaire consists of 7 items and the GAD-7 score can range from 0 to 21 points. The cut-off points for mild, moderate and severe anxiety are 5, 10 and 15, respectively.³⁹

Statistical analysis

The medical history, questionnaires and polysomnographic data were entered into a database and subjected to statistical analysis.

The non-parametric Kendall's Tau correlation coefficient was employed to assess the relationship between the variables, with the choice of the coefficient being determined by the fact that the variables did not have a normal distribution. A *p*-value for a correlation coefficient below 0.05 was considered statistically significant. The estimation of the sample size (*N*) was conducted using the power.cor function and the genefu package (<https://rdrr.io/bioc/genefu/man/power.cor.html>). The sample size for the Kendall correlation significance was calculated on the assumption that the expected value of the correlation coefficient would be 0.7 and that the expected width of the confidence interval would be 0.05. The calculated sample size was 22. Therefore, the 114 patients enrolled in the study constitute a sufficient base for the detection of differences and correlations between the examined parameters.

Results

Study sample

A total of 114 Caucasian adults (72 females and 42 males), aged 21–71 years (mean (*M*) = 37.67 years), participated in the study.

Relationship between pain and headache and subjective assessment of sleep quality

The severity of pain experienced by the participants was assessed using 4 independent questionnaires, as illustrated in Table 1. Taking into account the GCPS values, 64 participants reported experiencing low-intensity pain, with none to low pain-related disability (Grade I), 2 participants described their complaints as high-intensity pain without pain-related disability (Grade IIa), 15 stated that the pain they felt was of a high intensity and caused low pain-related disability (Grade IIb), 11 described their pain as a high-intensity pain causing moderately limiting disability (Grade III), while only 2 participants described their pain level as high-severity with severely limiting disability (Grade IV). The remaining participants did not report pain.

The HIT-6 questionnaire results provided information on the impact of HA on functioning at work, school, home, and in various social settings. The results indicated that 48 subjects reported little or no impact of HA on their daily activities, 14 subjects reported a slight impact, 11 individuals reported a significant impact, and a severe HA effect on daily activities was reported by 35 subjects.

Table 1. Questionnaire results on pain severity, impact of pain on daily activities, perceived disability due to pain, sleep quality, insomnia, and daytime sleepiness reported by the participants

Questionnaire	Result	Subjects <i>n</i> (%)
GCPS	Grade 0	20 (17.54)
	Grade I	64 (56.14)
	Grade IIa	2 (1.76)
	Grade IIb	15 (13.16)
	Grade III	11 (9.64)
	Grade IV	2 (1.76)
HIT-6	no or little impact	48 (44.44)
	slight impact	14 (12.96)
	significant impact	11 (10.19)
	severe impact	35 (32.41)
MIDAS	Grade I	52 (52.00)
	Grade II	10 (10.00)
	Grade III	15 (15.00)
	Grade IV	23 (23.00)
SF-MPQ	≤5	74 (64.91)
	>5	40 (35.09)
TMD pain screener	≤3	47 (53.41)
	>3	41 (46.59)
PSQI	≤5	36 (33.03)
	>5	73 (66.97)
ISI	normal	29 (32.59)
	subthreshold insomnia	33 (37.07)
	significant moderate insomnia	21 (23.60)
	severe insomnia	6 (6.74)
ESS	normal	61 (69.31)
	mild daytime sleepiness	18 (20.46)
	average daytime sleepiness	7 (7.96)

GCPS – Graded Chronic Pain Scale; HIT-6 – Headache Impact Test-6; MIDAS – Migraine Disability Assessment; SF-MPQ – short-form McGill Pain Questionnaire; TMD – temporomandibular disorders; PSQI – Pittsburgh Sleep Quality Index; ISI – Insomnia Severity Index; ESS – Epworth Sleepiness Scale.

The impact of HA on functioning at work, home and in social settings was assessed using the MIDAS scale. Participants were classified into 4 disability groups based on the number of days they had to limit their activities due to HA. Little or no disability was reported by 52 participants (Grade I), 10 reported mild disability (Grade II), 15 – moderate disability (Grade III), and 23 – severe disability (Grade IV). A clinically significant pain level was reported by 40 participants in the SF-MPQ study. The remaining participants did not report any pain, and the complaints were not clinically significant. At the same time, clinically significant TMD-related pain was recorded for 41 participants who completed the TMD pain screener.

The participants completed questionnaires designed to assess their sleep quality. In the PSQI, the cut-off point indicating poor sleep quality was reached by 73 subjects, while

36 subjects were classified as having normal sleep quality. The ISI indicated that 29 participants had normal sleep quality, 33 individuals had subthreshold insomnia, 21 – significant moderate insomnia, and 6 – severe insomnia. According to the ESS, 61 respondents exhibited no abnormalities, 18 displayed mild daytime sleepiness, 7 had average daytime sleepiness, and 2 exhibited severe daytime sleepiness. Table 1 provides a summary of the aforementioned results.

The Kendall's Tau correlation coefficient showed a statistically significant association between self-reported pain severity and decreased sleep quality. Furthermore, there was a correlation between greater pain and related disability, as assessed using the GCPS, and subjective sleep quality, as assessed using the PSQI and ISI questionnaires. The correlation between the increased pain reported in the SF-MPQ and the worsened sleep quality observed in the ISI and PSQI scores was statistically significant. Participants whose scores exceeded the cut-off point in the TMD pain screener exhibited a deterioration in sleep quality, as indicated by the ISI and PSQI scores. The relationship between the increase in pain complaints reported in the HIT-6 questionnaire and the deterioration in sleep quality observed in the PSQI, ISI and ESS questionnaires was also statistically significant. A similar relationship was observed between the MIDAS questionnaire

values and the PSQI, ISI and ESS scores. Consequently, the current research indicates that pain and related disability were the cause of poor sleep quality. Table 2 illustrates the presence of subjective sleep disturbances based on the increase in reported pain.

Relationship between pain and headache and the assessment of sleep quality in polysomnography

The quality of sleep was also objectively evaluated in a sleep research laboratory. All participants underwent a polysomnographic examination, which recorded the parameters necessary for the objective assessment of sleep quality. A statistical analysis was conducted, including the following polysomnographic parameters: total sleep time (TST), which represents the sum of time spent asleep in minutes; wake after sleep onset (WASO), which refers to waking up after falling asleep; sleep latency (SL), which is defined as the time from turning off the light to falling asleep (and is considered the first occurrence of non-rapid eye movement (NREM) stage 2); and sleep efficiency (SE), which is calculated as $TST/\text{total time in bed (TBT)} \times 100\%$. Table 3 presents the results of the polysomnographic examination.

Table 2. Presence of subjective sleep disturbances based on the increase in pain reported by the participants

Pair of variables	<i>n</i>	Kendall's Tau	<i>Z</i>	<i>p</i> -value
GCPS & PSQI global score	110	0.159381	2.468092	0.014*
GCPS & ISI	87	0.204041	2.798379	0.005*
GCPS & ESS	87	−0.007137	−0.097879	0.922
HIT-6 & PSQI global score	108	0.197245	3.025658	0.002*
HIT-6 & ISI	88	0.343241	4.735509	<0.001*
HIT-6 & ESS	85	0.254950	3.454555	0.001*
MIDAS & PSQI global score	101	0.248177	3.677424	<0.001*
MIDAS & ISI	82	0.410572	5.460118	<0.001*
MIDAS & ESS	81	0.164313	2.171236	0.030*
SF-MPQ & PSQI global score	114	0.290926	4.588840	<0.001*
SF-MPQ & ISI	89	0.359480	4.988756	<0.001*
SF-MPQ & ESS	88	0.138921	1.916616	0.055
TMD pain screener & PSQI global score	88	0.228828	3.157022	0.002*
TMD pain screener & ISI	66	0.272170	3.230833	0.001*
TMD pain screener & ESS	87	0.042816	0.587212	0.557

* statistically significant ($p < 0.05$, Kendall's Tau correlation).

Table 3. Results of polysomnographic examination

Parameter	<i>M</i>	<i>Me</i>	Minimum	Maximum	Lower quartile	Upper quartile	Quartile deviation	<i>SD</i>
TST	434.0883	449.0000	145.4000	530.5000	399.5000	481.2000	81.70000	68.62323
WASO	43.6350	29.5000	0.5000	171.0000	17.5000	57.0000	39.50000	38.13132
SL	19.0922	14.9000	0.3000	68.1000	6.6000	25.4000	18.80000	16.06708
SE	86.2447	88.1000	59.1000	97.9000	80.6000	93.4000	12.80000	8.75870

TST – total sleep time; WASO – wake after sleep onset; SL – sleep latency; SE – sleep efficiency; *M* – mean; *Me* – median; *SD* – standard deviation.

The results of the Kendall's Tau test were unexpected, as the quality of sleep measured during polysomnography did not show a statistically significant relationship with an increase in the intensity of reported pain and related disability. Only participants whose scores exceeded the cut-off point on the TMD pain screener demonstrated a reduction in the WASO parameter in the polysomnographic examination. The relationship between the increase in reported pain complaints in questionnaire studies and selected parameters assessed in polysomnography are presented in Table 4.

A statistical analysis was conducted to assess the relationship between the SE and SL measured in the polysomnographic examination. The parameters were defined by the participants as 2 of the 7 components of sleep quality in the PSQI questionnaire (C2 falling asleep – analysis of the SL in minutes and the number of nights where the SL was extended to more than 30 min; C4 SE – quantitative assessment of the ratio of TST to TBT). The results of the comparison between the SL and SE are presented in Table 5.

Table 4. Relationship between pain complaints reported in questionnaire studies and selected parameters of sleep quality assessed in polysomnography

Pair of variables	<i>n</i>	Kendall's Tau	<i>Z</i>	<i>p</i> -value
TMD pain screener & TST	80	−0.019701485	−0.25865555	0.796
TMD pain screener & WASO	80	−0.1873126	−2.45917716	0.014*
TMD pain screener & SL	80	0.0706424102	0.927445358	0.354
TMD pain screener & SE	80	0.0693498556	0.910475753	0.363
HIT-6 & TST	98	0.0455309984	0.664223607	0.507
HIT-6 & WASO	98	−0.102724483	−1.49858402	0.134
HIT-6 & SL	98	−0.035229518	−0.51394168	0.607
HIT-6 & SE	98	0.0281436189	0.41056987	0.681
MIDAS & TST	92	0.114810466	1.62095682	0.105
MIDAS & WASO	92	−0.094433626	−1.33326548	0.182
MIDAS & SL	92	0.0688945252	0.972690504	0.331
MIDAS & SE	92	0.0321546277	0.453976581	0.650
GCPS & TST	100	0.0637825268	0.940261478	0.347
GCPS & WASO	100	−0.060060854	−0.88539778	0.376
GCPS & SL	100	0.052715005	0.777107635	0.437
GCPS & SE	100	−0.016318200	−0.24055766	0.810

* statistically significant ($p < 0.05$, Kendall's Tau correlation).

Table 5. Comparison of sleep latency and sleep efficiency in questionnaire studies and polysomnographic examination

Pair of variables	<i>n</i>	Kendall's Tau	<i>Z</i>	<i>p</i> -value
TMD pain screener & SL	80	0.070642	0.927445	0.354
TMD pain screener & SE	80	0.069349	0.910475	0.363
TMD pain screener & PSQI SL	85	0.183346	2.48432	0.013*
TMD pain screener & PSQI habitual SE	85	0.164382	2.22736	0.026*
HIT-6 & SL	98	−0.035229	−0.51394	0.607
HIT-6 & SE	98	0.0281436	0.410569	0.681
HIT-6 & PSQI SL	107	0.053866	0.82232	0.411
HIT-6 & PSQI habitual SE	107	0.173293	2.64551	0.008*
MIDAS & SL	92	0.068894	0.97269	0.331
MIDAS & SE	92	0.032154	0.45397	0.650
MIDAS & PSQI SL	100	0.166755	2.45825	0.014*
MIDAS & PSQI habitual SE	100	0.211255	3.11425	0.002*
GCPS & SL	100	0.052715	0.77710	0.437
GCPS & SE	100	−0.016318	−0.24055	0.810
GCPS & PSQI SL	107	0.019255	0.29394	0.769
GCPS & PSQI habitual SE	107	0.109976	1.67891	0.093

* statistically significant ($p < 0.05$, Kendall's Tau correlation).

The relationship between sleep quality parameters derived from polysomnography and sleep quality as assessed subjectively by participants in questionnaire studies is summarized in Table 6. The lack of correlation between these parameters confirms that subjectively assessed sleep quality is influenced by factors other than pain, as pain alone did not correlate with the occurrence of sleep disorders in the polysomnographic examination.

Relationship between the level of anxiety, depression and stress, and the subjective assessment of sleep quality

The PSS-10 and KPS questionnaires assessed perceived stress levels, the BDI and PHQ-9 evaluated depression, and the GAD-7 and BAI measured anxiety. Table 7 presents the number of participants at risk of psycho-emotional disturbances, defined as an increased sense of anxiety, stress and/or depression.

The statistical analysis revealed a significant correlation between the occurrence of pain, its severity and pain-related disability that causes limitations in everyday professional, family and social activities and affects the participants' psycho-emotional state. This relationship is presented in Table 8.

The relationship between subjective sleep disturbances and the psycho-emotional state was significant. Increased anxiety, stress and depression scores correlated with a decrease in subjective sleep quality. Furthermore, a decreased psycho-emotional status was consistently correlated with increased participant complaints of poor sleep

Table 7. Stress, anxiety and depression levels reported by the participants

Questionnaire	Result	Subjects <i>n</i> (%)
PSS-10	low level of stress	30 (27.78)
	moderate level of stress	65 (60.19)
	high level of stress	13 (12.04)
KPS	STEN 1–4	74 (66.67)
	STEN 5–6	26 (23.42)
	STEN 7–10	11 (9.91)
BDI	no depression	72 (65.45)
	mild depression	22 (20.00)
	moderate depression	11 (10.00)
	severe depression	5 (4.55)
PHQ-9	no depression	33 (30.28)
	mild depression	41 (37.61)
	moderate depression	24 (22.02)
	moderately severe depression	8 (7.34)
	severe depression	3 (2.75)
GAD-7	minimal anxiety	55 (51.89)
	mild anxiety	33 (31.13)
	moderate anxiety	11 (10.38)
	severe anxiety	7 (6.60)
BAI	minimal anxiety	77 (73.33)
	moderate anxiety	16 (15.24)
	severe anxiety	12 (11.43)

PSS-10 – Perceived Stress Scale-10; KPS – Sense of Stress Questionnaire; BDI – Beck Depression Inventory; PHQ-9 – Patient Health Questionnaire-9; GAD-7 – Generalized Anxiety Disorder-7; BAI – Beck Anxiety Inventory.

Table 6. Comparison of sleep quality parameters derived from polysomnography with those obtained in questionnaire studies

Pair of variables	<i>n</i>	Kendall's Tau	<i>Z</i>	<i>p</i> -value
TST & ISI	81	0.091348	1.20708	0.227
TST & ESS	81	0.074740	0.98762	0.323
TST & PSQI global score	103	0.101410	1.51797	0.129
WASO & ISI	81	0.021504	0.28415	0.776
WASO & ESS	81	−0.110765	−1.46365	0.143
WASO & PSQI global score	103	0.008127	0.12165	0.903
SL & ISI	81	0.104323	1.37853	0.168
SL & ESS	81	−0.068686	−0.90762	0.364
SL & PSQI global score	103	0.0257558	0.38553	0.700
SE & ISI	81	−0.039522	−0.5222	0.601
SE & ESS	81	0.1059903	1.40056	0.161
SE & PSQI global score	103	−0.052512	−0.7860	0.432
GCPS & SL	100	0.052715	0.77710	0.437
GCPS & SE	100	−0.016318	−0.24055	0.810
GCPS & PSQI SL	107	0.019255	0.29394	0.769
GCPS & PSQI habitual SE	107	0.109976	1.67891	0.093

* statistically significant ($p < 0.05$, Kendall's Tau correlation).

quality (as measured by the PSQI), increased daytime sleepiness (as measured by the ESS) and increased insomnia severity (as measured by the ISI). The relationship was more pronounced than that between perceived pain and the subjective assessment of sleep quality. Therefore, the psycho-emotional state of patients may be a factor influencing their perception of sleep quality (Table 9).

Relationship between the level of anxiety, depression and stress, and the objective assessment of sleep quality in polysomnography

The analysis of the impact of the psycho-emotional state on sleep quality, as measured using polysomnography, revealed that the relationship between the 2 variables is not straightforward or statistically unambiguous. Patients with higher stress levels (as measured by the KPS) exhibited a shortened TST ($p = 0.017$), worse SE ($p = 0.031$), longer SL ($p = 0.030$), and a longer WASO ($p = 0.028$). However, this relationship was only found for TST ($p = 0.049$) when measuring stress levels using the PSS-10. There was no longer a significant correlation with

WASO ($p = 0.115$), SL ($p = 0.615$) or SE ($p = 0.235$). The examination of other sleep parameters during polysomnography did not reveal any abnormalities in participants with elevated levels of stress, anxiety or depression. The data is presented in Table 10.

Discussion

The objective of the study was to determine the relationship between reported OFP, HA and sleep quality using subjective and objective assessment methods. The study also aimed to explore whether the poor quality of sleep was only related to OFP and HA, or whether it was influenced by the coexistence of psycho-emotional factors such as depression, anxiety and stress. Even though the relationship between OFP and HA and the deterioration of sleep quality was reported by patients in questionnaire studies, no significant deviations were found in the objective study using polysomnography despite complaints reported by patients. However, the study revealed that patients who reported reduced sleep quality in questionnaire studies also exhibited elevated levels of stress, anxiety and depression.

Table 8. Relationship between the level of anxiety, depression and stress, and pain severity

Pair of variables	<i>n</i>	Kendall's Tau	<i>Z</i>	<i>p</i> -value
TMD pain screener & PSS-10	85	0.271585	3.679949	<0.001*
TMD pain screener & KPS	87	0.245056	3.360890	0.001*
TMD pain screener & BDI	86	0.280451	3.823269	<0.001*
TMD pain screener & PHQ-9	86	0.327406	4.463393	<0.001*
TMD pain screener & BAI	83	0.330526	4.423432	<0.001*
TMD pain screener & GAD-7	83	0.370594	4.959670	<0.001*
GCPS & PSS-10	106	0.273809	4.159796	<0.001*
GCPS & KPS	109	0.193104	2.976261	0.003
GCPS & BDI	108	0.250197	3.837918	<0.001*
GCPS & PHQ-9	108	0.273731	4.198926	<0.001*
GCPS & BAI	104	0.302987	4.558022	<0.001*
GCPS & GAD-7	104	0.293885	4.421089	<0.001*
HIT-6 & PSS-10	108	0.226315	3.471580	0.001*
HIT-6 & KPS	107	0.300810	4.592199	<0.001*
HIT-6 & BDI	108	0.348665	5.348384	<0.001*
HIT-6 & PHQ-9	107	0.330598	5.046953	<0.001*
HIT-6 & BAI	104	0.319397	4.804873	<0.001*
HIT-6 & GAD-7	105	0.310308	4.691280	<0.001*
MIDAS & PSS-10	100	0.330638	4.874154	<0.001*
MIDAS & KPS	100	0.275152	4.056203	<0.001*
MIDAS & BDI	101	0.400234	5.930566	<0.001*
MIDAS & PHQ-9	101	0.332793	4.931234	<0.001*
MIDAS & BAI	99	0.377552	5.536881	<0.001*
MIDAS & GAD-7	99	0.328361	4.815483	<0.001*

* statistically significant ($p < 0.05$, Kendall's Tau correlation).

Table 9. Relationship between the level of anxiety, depression and stress, and the subjective assessment of sleep quality

Pair of variables	<i>n</i>	Kendall's Tau	<i>Z</i>	<i>p</i> -value
PSS-10 & PSQI	108	0.324845	4.982985	<0.001*
PSS-10 & ISI	88	0.394190	5.438427	<0.001*
PSS-10 & ESS	85	0.212189	2.875137	0.004*
KPS & PSQI	112	0.302435	4.727067	<0.001*
KPS & ISI	88	0.339918	4.689672	<0.001*
KPS & ESS	87	0.200043	2.743542	0.006*
BDI & PSQI	110	0.405912	6.285733	<0.001*
BDI & ISI	88	0.428127	5.906635	<0.001*
BDI & ESS	86	0.272479	3.714598	<0.001*
PHQ-9 & PSQI	109	0.437751	6.746935	<0.001*
PHQ-9 & ISI	87	0.480670	6.592274	<0.001*
PHQ-9 & ESS	86	0.341903	4.661024	<0.001*
BAI & PSQI	106	0.402993	6.122401	<0.001*
BAI & ISI	85	0.409755	5.552148	<0.001*
BAI & ESS	83	0.192642	2.578127	0.010*
GAD-7 & PSQI	106	0.355888	5.406769	<0.001*
GAD-7 & ISI	86	0.428333	5.839290	<0.001*
GAD-7 & ESS	84	0.208219	2.804021	0.005*

* statistically significant ($p < 0.05$, Kendall's Tau correlation).**Table 10.** Relationship between the level of anxiety, depression and stress, and the objective assessment of sleep quality in polysomnography

Pair of variables	<i>n</i>	Kendall's Tau	<i>Z</i>	<i>p</i> -value
PSS-10 & TST	98	0.135076	1.97055	0.049*
PSS-10 & WASO	98	-0.108172	-1.57806	0.115
PSS-10 & SL	98	-0.034472	-0.50289	0.615
PSS-10 & SE	98	0.081371	1.18708	0.235
KPS & TST	102	0.159898	2.38142	0.017*
KPS & WASO	102	-0.147246	-2.19299	0.028*
KPS & SL	102	-0.145709	-2.17009	0.030*
KPS & SE	102	0.1446899	2.1549	0.031*
BDI & TST	100	0.074851	1.10343	0.270
BDI & WASO	100	-0.080055	-1.18014	0.238
BDI & SL	100	-0.1006566	-1.483847	0.138
BDI & SE	100	0.08106160	1.1949840	0.232
PHQ-9 & TST	99	0.072239	1.05941	0.289
PHQ-9 & WASO	99	-0.098424	-1.44341	0.149
PHQ-9 & SL	99	0.0114757	0.168293	0.866
PHQ-9 & SE	99	0.0490954	0.719996	0.472
BAI & TST	96	0.106368	1.53526	0.125
BAI & WASO	96	-0.075987	-1.09676	0.273
BAI & SL	96	0.01954793	0.282144	0.778
BAI & SE	96	0.02843335	0.410392	0.682
GAD-7 & TST	98	0.125856	1.83603	0.066
GAD-7 & WASO	98	-0.077735	-1.13403	0.257
GAD-7 & SL	98	0.078594	1.146563	0.252
GAD-7 & SE	98	0.028898	0.421578	0.673

* statistically significant ($p < 0.05$, Kendall's Tau correlation).

Many studies have demonstrated that individuals with severe and prolonged pain and HA exhibit elevated levels of stress, anxiety and depression. These studies also indicated that psycho-social factors play a vital role in predisposing to, and the course of, severe pain or HA and their treatment.^{40–42} Such a relationship is in line with the results of the current study, which confirms the crucial role of the psycho-emotional state of patients suffering from pain in the course of the disease and the selection of treatment methods, which should aim to improve patient well-being and include psychological consultations and, if required, psychiatric consultations for support and multi-directional therapy.

Yap et al. examined the effect of the severity of TMD pain on sleep quality and the impact of TMD diagnosis type on sleep disorders.⁴³ Their findings indicated that individuals with moderate to severe pain had significantly worse sleep than those with mild pain. Participants with pain-related and/or intra-articular TMD reported significantly worse sleep quality than TMD-free controls. In addition, individuals with muscle pain and those with muscle pain and joint pain presented significantly worse sleep than those with non-painful joint disorders. However, in this study, sleep quality was only assessed using the PSQI.⁴³ Kim and Kim also reported significant differences in global PSQI scores between 3 pain diagnosis groups in Korean TMD patients.⁴⁴ Other authors indicated that reduced sleep quality in participants with pain associated with TMD can negatively impact treatment outcomes and quality of life.^{45,46} The findings of the cited studies contrast with the results of the current study, which indicate pain as the primary cause of sleep quality abnormalities reported by patients. On the other hand, Yatani et al. demonstrated that poor sleep quality may not be solely attributed to elevated pain severity.⁴⁷ Their findings indicated that psychological distress and low perceived life control contributed to reduced sleep quality.⁴⁷ A similar conclusion can be drawn from the observations in the current study.

When discussing the issue of pain and sleep quality, it is important to consider the neurobiological aspect of OFP and the neural processes underlying sleep, particularly the mechanisms underlying the interactions between pain and sleep, including sleep disturbances. Chronic pain is often associated with poor sleep quality, which can also be a cause of pain. This interdependence indicates that the reduction of OFP and the improvement of sleep quality should be targeted together.²⁰ Patients with chronic pain tend to exhibit either short or long sleep durations and also experience depressive mood symptoms.^{48,49} According to other authors, chronic pain may increase the risk of insomnia,⁵⁰ and insomnia may be associated with a reduction in pain tolerance and lower SE.⁵¹

Lavigne and Sessle state that, during normal sleep in healthy adults, nociceptive transmission is partially impaired to maintain sleep continuity, resulting in a higher

threshold of excitability or a lower rate of response to noxious stimuli in light sleep (stages N1 and N2) and in deep sleep (stage N3), where it is even more important.²⁰ However, this relationship is variable in REM sleep. These processes ensure that low-intensity stimuli have little or no effect on the quality of sleep if the sleep takes place in good conditions.²⁰ Consequently, the link between pain and sleep quality, especially chronic pain, is indisputable. However, it must not be forgotten that there are also processes that prevent ailments from affecting the quality and course of sleep.

In their study, Dubrovsky et al. employed double-night polysomnography to assess sleep quality, using Symptom Checklist-90 to evaluate depressive symptoms and the PSQI to assess subjective sleep quality.⁵² The findings of their study were comparable to those of the current study. Increased self-reported sleep problems in women with myofascial pain were more attributable to reporting depressive symptoms than to pain intensity or objective polysomnography measures. The authors warned against assuming that myofascial pain is associated with poor sleep quality and highlighted the potential of questionnaire studies such as the PSQI to effectively diagnose the presence of sleep disorders in study participants. Furthermore, the authors advised that more attention should be paid to the necessity of objective sleep quality diagnostics, which can be achieved through polysomnographic examination. This method does not often show deviations from the norm. As such, the poor sleep quality reported by patients suffering from pain may be caused by psycho-emotional disturbances.⁵² In contrast, Smith et al. revealed that approx. 36% of participants with TMD pain suffered from insomnia, 28% had sleep apnea, and some patients were also diagnosed with a mild form of sleep-disordered breathing known as respiratory effort-related arousals.⁵³

When considering the relationship between pain, sleep quality and the psycho-emotional state, it is important to acknowledge the role of the pituitary hormones pathway. The daily rhythm of cortisol secretion is relatively stable and primarily under the influence of the circadian clock. Moreover, the activity of the hypothalamic–pituitary–adrenal (HPA) axis is modulated by many different factors, of which sleep has a modest but significant impact. Sleep onset has an inhibitory effect on cortisol secretion, while awakenings and sleep offset are associated with cortisol stimulation. During waking, a correlation between cortisol secretory bursts and indices of central arousal has also been detected. A lack of sleep and/or a reduction in sleep quality results in a slight activation of the axis, while sudden changes in sleep duration cause a profound disruption of the circadian rhythm of cortisol.⁵⁴ The HPA axis is also vital for stress adaptation, with its activation causing the secretion of glucocorticoids. The HPA stress response is primarily driven by neural mechanisms and involves the release of corticotropin-releasing hormone (CRH) from hypothalamic paraventricular nucleus (PVN) neurons.

The pathways that activate CRH release are stressor dependent. Reactive responses to homeostatic disruption frequently involve direct noradrenergic or peptidergic drive of PVN neurons by sensory relays, whereas anticipatory responses use oligosynaptic pathways originating in upstream limbic structures. These relationships are complex and require further study.^{54,55}

Many studies have been conducted on the relationship between pain and sleep disorders. The results of some of these studies are presented in this paper. However, only one of these studies used a subjective assessment of sleep quality, i.e., polysomnography. In the current study, all patients underwent a polysomnographic examination, which enabled a comparison of their reports of poorer sleep quality with the objective sleep quality parameters derived from polysomnography. An additional advantage of this study was the comparison of pain levels and sleep quality reported by patients and sleep parameters from polysomnography with the psycho-emotional state of the patients.

Limitations

The limitations of the study relate to the use of single-night video-polysomnography and the discrepancy between the sleep laboratory environment and the participant's usual sleeping conditions. The negative impact of the new environment on sleep quality is most pronounced during the first night spent in the sleep laboratory. Another limitation of the current research was the use of questionnaires to diagnose pain and HA, with no instrument used to objectively measure pain severity. Additionally, the analysis of the examined relationships did not account for gender.

Conclusions

Orofacial pain (OFP resembling presentations of primary HA, myofascial OFP and TMJ pain) and HA are serious and very common problems. Among the difficulties reported by patients dealing with pain, sleep disturbances are frequently observed. As such, the role of sleep disorders in pain patients cannot be neglected, and the possibility of sleep disturbances, sleep apnea, sleep-related hypoxia, and insomnia in patients with OFP or HA should always be considered. However, the results of this study indicate that the poor sleep quality reported by a patient may not be related to sleep disorders as determined by polysomnographic examination. Indeed, long-term pain is frequently associated with the co-occurrence of disorders of the patient's psycho-emotional state, including anxiety, depression and increased stress levels. Therefore, the psycho-emotional state of a patient suffering from pain may be the underlying cause of the subjective deterioration in sleep quality. Consequently, patients with

long-lasting pain should also be examined for psycho-emotional disorders and, if indicated, provided with professional care.

Self-reporting of poor sleep quality may be enhanced by the incorporation of polysomnography into the diagnostic process, which should be considered the gold standard for the diagnosis of sleep disorders. Therefore, the identification of comorbidities, a detailed study of the psycho-emotional state of the patient, and questionnaire studies on sleep quality are essential for selecting the most effective management strategy for patients with OFP or HA. The current study found that the presence and intensity of patient-reported OFP and HA reduced sleep quality subjectively, but not objectively. Furthermore, these relationships were impacted by the presence of psycho-emotional disorders. However, the lack of comprehensive data on the mechanisms involved in the interactions between OFP and sleep warrants further research.

Ethics approval and consent to participate

The study protocol was approved by the Ethical Committee of Wrocław Medical University (approval No. KB-794/2019). All study participants were informed of the purpose of the study and consented to participate. The study was conducted in accordance with the Declaration of Helsinki for research involving human subjects.

Data availability

The data that supports the findings of this study is available from the corresponding author on reasonable request. The data is not publicly available due to privacy or ethical restrictions.

Consent for publication

Not applicable.

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