

# The correlation between shoulder pathologies and sleep disorders

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## Abstract

**Objective:** To assess and characterize the correlation between shoulder pathologies and sleep disturbances.

**Methods:** Participants enrolled into this case–control study were divided into two groups: patients with an established clinical diagnosis of active shoulder pathology (study group), and patients without any shoulder pathology (control group). All patients completed the Insomnia Severity Index (ISI) questionnaire, in addition to questions related to participant demographics, health status, medication, and other known insomnia risk factors.

**Results:** A total of 98 patients were included (46 in the study group and 52 controls). Mean ISI score was significantly higher (indicating more severe insomnia) in the study group versus control group ( $t[96] = -9.67$ ), even after correcting for confounders ( $t[53.1] = -8.61$ ). Additionally, in patients with shoulder pathology, those with comorbidities experienced more sleep disturbances than those without comorbidities ( $\beta = 0.36$ ). Lastly, the shoulder pathology group was at a higher risk of having sleep disturbances compared with controls (relative risk 4.86, 95% confidence interval 2.24, 10.55).

**Conclusions:** Sleep disturbances are more common among patients with shoulder pathologies. Comorbidities and a shorter duration of pathology may predict more severe sleep disturbances.

## Keywords

Insomnia, rotator cuff, shoulder, sleep, insomnia severity index, sleep disturbance

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## Introduction

Insomnia (sleep disturbance) is very common, affecting approximately 30% of the general population. A long sleep latency, frequent night awakenings, or prolonged periods of arousal during time 'dedicated' to sleep can be considered reflective of insomnia. As many as 40% of adults with insomnia are thought to be affected by an additional psychiatric disorder, mainly in the form of depression.<sup>1</sup>

Risk factors related to a higher incidence of insomnia include older age, female sex, and medical (particularly psychiatric) pathologies. Sleep disturbances are detrimental to cognitive and physical functions and are also associated with a variety of functional disabilities in several mental and emotional areas during waking hours.<sup>2</sup> Patients with sleep disturbances and related pathologies are more prone to be involved in motor vehicle accidents, have higher absence rates from work and worse work performance,<sup>3</sup> experience a decreased quality of life (QoL), and are more inclined to use the medical system.<sup>4</sup>

There are numerous reasons for sleep disturbances, including the consumption of certain medications; use of substances, such as drugs, cigarettes, or alcohol; consumption of caffeine containing products;<sup>5</sup> chronic medical conditions, such as type 2 diabetes mellitus,<sup>6</sup> respiratory illnesses, and nervous system pathologies.<sup>7</sup>

Pain is one of the main underlying factors in the development of sleep disorders, as the body is in a constant state of hyper arousal that can worsen sleep disturbances, which may, in turn, increase one's distress and difficulty falling asleep.<sup>8</sup> Night awakening pain is considered a primary problem in patients with various shoulder pathologies, particularly rotator cuff syndrome or shoulder impingement syndrome, characterized by the rotator cuff tendons and the subacromial bursa being pinched in the narrow

space beneath the acromion, or a partial or complete rotator cuff tear. Arthritis and adhesive capsulitis, also known as frozen shoulder, characterized by pain and significant range of motion limitations in the shoulder, are other conditions linked to insomnia.<sup>9–13</sup>

The specific cause of night pain in shoulder pathologies remains unclear, and different theories have been proposed, including high subacromial pressure due to the accumulation of fluid in the subacromial bursa.<sup>14,15</sup> Skin temperature changes,<sup>16</sup> synovitis,<sup>17,18</sup> and increased blood flow in the anterior humeral circumflex artery have also been suggested as contributing factors.<sup>19</sup>

Sleep disturbances are well known to often appear alongside shoulder pathologies. However, these have not been studied in relation to their characteristics, and there is a paucity of data regarding quality of sleep, number of awakenings, and difficulty in falling asleep. The aim of the present study was to confirm, assess, and characterize the correlation between shoulder pathologies and sleep disturbances, based on the hypothesis that sleep disturbances are more common among patients with shoulder pathologies, and that the relative risk (RR) for such sleep disturbances will be found among risk factors concerning the duration of shoulder pathology and comorbidities that may predict more severe sleep disturbances.

## Patients and methods

### Study population

This observational case-control study followed the tenets of the Declaration of Helsinki, and was approved by the Emek Medical Centre Ethics Committee. Written informed consent was obtained from all participants and copies of the written consent are available for review by the

Editor-in-Chief of this journal. The reporting of this study conforms to STROBE guidelines.<sup>20</sup>

The study included two groups: patients with an established clinical diagnosis of active shoulder pathology who were randomly recruited from the orthopaedic clinic of Emek Medical Centre, Afula, Israel between September 2020 and March 2021, prior to undergoing surgery (study group), and patients without any prior history of shoulder or sleep pathology who were seeking treatment at the same clinic during the same time period (control group). Patients aged <18 years, patients with concomitant or treated sleep disturbances, patients with non-shoulder related acute or chronic pain, patients diagnosed with psychiatric or neurologic disorders, and patients with concomitant shoulder pathologies were excluded from the study.

During the clinic appointment at which they were recruited, patients completed the Insomnia Severity Index (ISI) questionnaire, in addition to questions addressing their demographics, health status, medication, and other known insomnia risk factors. The collected data were statistically analysed with consideration of the confounding effects of other risk factors, in order to best understand the pattern, severity, and correlation dynamics of insomnia among participants.

### **Evaluation tools**

The severity of insomnia was determined with the ISI questionnaire.<sup>21–23</sup> The questionnaire includes seven items and its purpose is to assess the existence, severity, and effect of insomnia in adults, for example: ‘How much do you consider the sleep problem interferes with your functioning (fatigue, mood, concentration, memory, doing work)?’. Each item is answered with a severity score ranging from 0 to 4, and for each participant, the sum of the answers in

the questionnaire is calculated. A high total score on the questionnaire indicates the likely presence of problematic sleep disturbance. In addition, the accumulated score can be divided into four severity categories, such that 0–7 reflects no significant sleep disturbance, 8–14 reflects subclinical sleep disturbance, 15–21 reflects moderate sleep disturbance, and 22–28 reflects severe sleep disturbance.

In addition to the ISI questionnaire, patients were characterized using questions about their demographics (age, weight, and height), shoulder pathology (type, location, and duration), habits (caffeine consumption, smoking, and alcohol/substance use), health status (comorbidities, medications, and sedative use), and history of sleep disorder.

### **Statistical analyses**

Data are presented as mean  $\pm$  SD or *n* (%) prevalence, and were analysed using SPSS, version 24 (IBM Corp; Armonk, NY, USA). Between-group differences in categorical variables were assessed with  $\chi^2$ -test. Student’s independent samples *t*-test was applied to assess between-group differences in continuous variables, including mean ISI scores. Two-way analysis of variance (ANOVA) was used to test the effect of shoulder pathology on ISI scores. Multiple linear regression was performed to assess the predictive values of pathology severity, pathology duration, and sex with regard to the sleep disorder. RR was calculated to examine the probability of developing insomnia in the study group. A two-sided *P*-value  $\leq 0.05$  was considered statistically significant.

### **Results**

A total of 106 patients were initially enrolled and divided into study and control groups (53 patients in each) who completed

the ISI questionnaire, in addition to questions regarding demographics, health status, medication, and other known insomnia risk factors. After excluding eight patients due to a known sleep problem, 98 patients were included in the final analyses (46 patients in the shoulder pathology [study] group and 52 patients in the control group; Table 1). Based on power analysis,<sup>24</sup> 98 participants yield 92.5% power under medium (0.3) effect size. The overall mean age was  $54.01 \pm 12.76$  years (range, 21–81 years). Mean age in the study group ( $60 \pm 11.27$  years) was significantly higher than in the control group ( $48.8 \pm 11.75$  years;  $t[96] = -4.77$ ,  $P < 0.001$ ). The mean body mass index (BMI) was also significantly higher in the study group ( $27.30 \pm 4.56$  kg/m<sup>2</sup>) compared with the control group ( $26.2 \pm 5$  kg/m<sup>2</sup>;  $t [98.36] = -2.45$ ,  $P < 0.05$ ). The duration of shoulder pathology in the

study group ranged from 4 to 96 months (mean duration,  $22.33 \pm 21.65$  months).

The distribution of shoulder pathology types among patients in the study group is summarised in Table 2; and the distribution of ISI questionnaire results among all patients included in the study is shown in Table 3.

The overall mean ISI score was  $11.8 \pm 8.75$ . Student's independent samples *t*-test revealed that the mean ISI score was

**Table 2.** Distribution of shoulder pathology types among patients in the study group.

Pathology type	Study group (n = 46)
Adhesive capsulitis	6 (13)
Partial rotator cuff tear	17 (37)
Complete rotator cuff tear	23 (50)

Data presented as n (%) prevalence.

**Table 1.** Characteristics of 98 patients grouped according to presence (study group) or absence (control group) of shoulder pathology.

Variable	Study group (n = 46)	Control group (n = 52)	Statistical significance (df) <sup>2</sup> χ
Sex			
Male	26 (56.5)	26 (50.0)	0.417 (1)
Female	20 (43.5)	26 (50.0)	
Comorbidity			
Yes	27 (58.7)	17 (32.7)	10.91 (1)**
No	19 (41.3)	35 (67.3)	
Medication use			
Yes	27 (58.7)	11 (21.2)	14.5 (1)**
No	19 (41.3)	41 (78.8)	
Sedative use			
Yes	2 (4.3)	0 (0.0)	2.31 (1)
No	44 (95.7)	52 (100)	
Smoking			
Yes	10 (21.7)	9 (17.3)	0.31 (1)
No	36 (78.3)	43 (82.7)	
Caffeine use ( $\geq 2$ cups of coffee)			
Yes	6 (13.0)	5 (9.6)	0.332 (1)
No	39 (84.8)	47 (90.4)	

Data presented as n (%) prevalence.

\*\* $P < 0.01$  ( $\chi^2$ -test).

**Table 3.** Distribution of Insomnia Severity Index (ISI) questionnaire responses among all 98 patients included in the study.

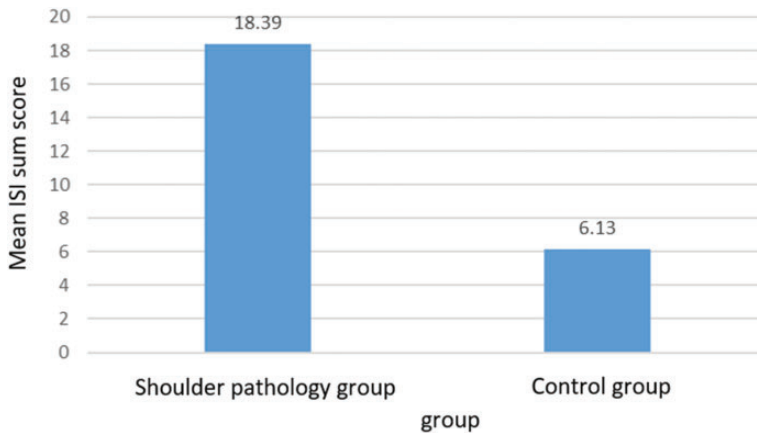
	0		1		2		3		4	
	Study	Control	Study	Control	Study	Control	Study	Control	Study	Control
Difficulty falling asleep	10 (21.7)	33 (63.5)	4 (8.7)	8 (15.4)	10 (21.7)	9 (17.3)	10 (21.7)	1 (1.9)	15 (28.3)	1 (1.9)
Difficulty staying asleep	5 (10.9)	21 (40.4)	3 (6.5)	17 (32.7)	7 (15.2)	13 (25.0)	18 (39.1)	0 (0)	13 (28.3)	1 (1.9)
Problems waking up too early	4 (8.7)	26 (50.0)	3 (6.5)	13 (25.0)	11 (23.9)	9 (17.3)	12 (26.1)	3 (6.5)	16 (34.8)	1 (1.9)
How satisfied/dissatisfied are you with your current sleep pattern?	0 (0)	15 (28.3)	5 (10.9)	13 (25.0)	7 (15.2)	15 (28.8)	19 (41.3)	8 (15.4)	15 (32.6)	1 (1.9)
How noticeable to others do you think your sleep problem is in terms of impairing the quality of your life?	7 (15.2)	30 (57.7)	4 (8.7)	13 (25.0)	11 (23.9)	4 (7.7)	9 (19.6)	4 (7.7)	15 (32.6)	1 (1.9)
How worried/distressed are you about your current sleep problem?	6 (13.0)	28 (53.8)	5 (10.9)	12 (23.1)	4 (8.7)	8 (15.4)	13 (28.3)	4 (7.7)	18 (39.1)	0 (0.0)
To what extent do you consider your sleep problem to interfere with your daily functioning (e.g., daytime fatigue, mood, ability to function at work/daily chores, concentration, memory, mood, etc) currently?	6 (13.0)	26 (50.0)	3 (6.5)	14 (26.9)	8 (17.4)	5 (9.6)	17 (32.1)	6 (11.3)	17 (37.0)	2 (3.8)

Data presented as n (%) prevalence.

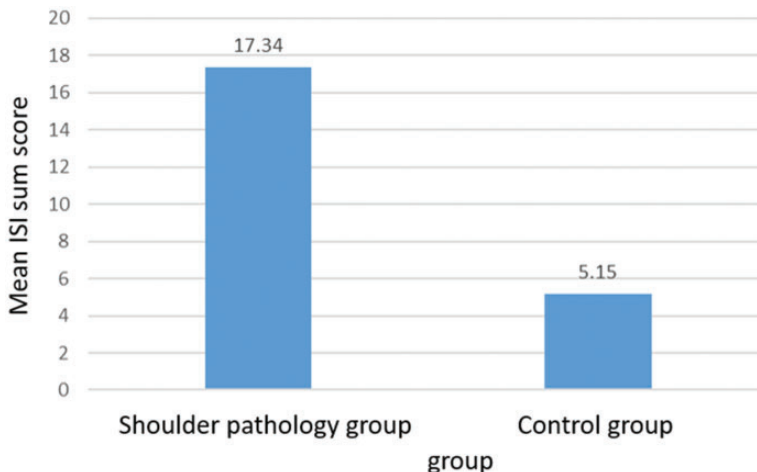
significantly higher in the study group than in the control group ( $18.39 \pm 6.9$  versus  $6.13 \pm 5.59$ , respectively;  $t[96] = -9.67$ ,  $P < 0.001$ ; Figure 1).

After excluding patients who used caffeine, alcohol, cigarettes and opiates ( $n = 72$ ), Student's independent samples  $t$ -test showed that ISI sum scores remained significantly higher in the study group versus the control group ( $17.34 \pm 7.06$  versus  $5.15 \pm 4.94$ ,  $t[53.51] = -8.61$ ,

$P < 0.001$ ; Figure 2). Student's independent samples  $t$ -test was then applied to test the hypothesis that there would be between-group differences in the first three ISI questions (i.e., Difficulty falling asleep, Difficulty staying asleep, and Problems waking up too early). ISI sum scores for these three questions were shown to be significantly higher in the study group versus the control group ( $7.61 \pm 3.16$  versus  $2.38 \pm 2.51$ ,  $t[96] = -9.28$ ,  $P < 0.001$ ).



**Figure 1.** Comparison of mean Insomnia Severity Index (ISI) questionnaire sum scores between patients with shoulder pathology ( $n = 46$ ) and patients without shoulder pathology (control group,  $n = 52$ ).



**Figure 2.** Comparison of mean Insomnia Severity Index (ISI) questionnaire sum scores between patients with shoulder pathology ( $n = 32$ ) and patients without shoulder pathology (control group,  $n = 40$ ) after excluding those using alcohol, cigarettes, caffeine and opiates.

Next, a two-way ANOVA was conducted to assess the effect of having a shoulder pathology, beyond comorbidities, on ISI score (meaning main effect of study group). The results yielded a significant main effect of the study group ( $F [1, 94] = 84.85, P < 0.001$ ), such that the study group exhibited a higher mean ISI score versus the controls ( $18.39 \pm 6.93$  versus  $6.13 \pm 5.59$ , respectively). The analysis did not yield a significant interaction effect (study group  $\times$  comorbidities;  $F [1, 94] = 2.82, P > 0.05$ ).

Multiple regression was conducted to assess the prognostic values of pathology duration and concomitant comorbidities regarding the severity of insomnia (with comorbidities coded as the dummy variable). These variables showed good prognostic value, explaining 47.5% of the variance of insomnia ( $F [2, 33] = 4.79, P < 0.05$ ).

No statistically significant correlation was found between duration of shoulder pathology and severity of insomnia ( $\beta = -0.30, P > 0.05$ ). However, patients with shoulder pathology plus comorbidities experienced more sleep disturbances than those with shoulder pathology without comorbidities ( $\beta = 0.36, P < 0.05$ ; Table 4).

Lastly, the RR was calculated to examine the probability of developing insomnia in the study group. For a dichotomous determination, an ISI index of 0–7 was considered to be negative for insomnia, and an ISI index  $\geq 8$  was considered positive for insomnia. The RR was calculated to 4.86 (95% confidence interval 2.24, 10.55).

## Discussion

In the present prospective case–control study of the associations between shoulder pathologies and insomnia, measured using the ISI questionnaire,<sup>21</sup> patients with shoulder pathologies were demonstrated to have higher ISI scores than the control group, meaning that they experienced worse insomnia. This included greater trouble falling asleep, night awakenings, and waking up too early. These results remained, even after correcting for confounders known to damage the quality of sleep (alcohol, cigarettes, caffeine, and opiate use/misuse).<sup>5,25</sup> The relative risk of experiencing sleep disturbances in a patient with shoulder pathology was found to be 4.86. In a systematic review, Kunze et al.<sup>26</sup> found that poor sleep quality improves 6 months after arthroscopic rotator cuff repair.

Findings regarding the association between duration of shoulder pathology and insomnia were not found to be statistically significant, which may have been due to the small sample size. However, despite the lack of significance, the trend regarding duration of pathology should be further investigated as a predictor of insomnia, in that the shorter the duration of shoulder pathology, the worse the sleeping disorders may be. Comorbidities that accompany a shoulder pathology predict worse insomnia symptoms. In the present study, comorbidities, smoking, and medication use were shown to predict severe insomnia, which is consistent with the work of Khazzam et al.,<sup>27</sup> who showed that the presence of comorbidities, smoking, and the use of

**Table 4.** Multiple regression to predict the severity of insomnia based on pathology duration and comorbidities in 46 patients with shoulder pathology.

Predictive variable	B	SE	$\beta$	Statistical significance
Duration of pathology	-0.09	0.05	-0.30	P = 0.06
Comorbidities	5.01	2.03	0.36	P = 0.02

medication in patients with rotator cuff pathologies worsen sleeping disturbances.

A higher prevalence of sleeping disorders has been shown in patients with shoulder pain for 3 months or more, only 18.4% of whom were diagnosed with adhesive capsulitis.<sup>28</sup> These findings were consistent with the present study that included a group of patients with shoulder pathology for an average duration exceeding three months, in which the study group showed significantly more sleep disturbances than the control group.

The biological mechanism underlying sleep disturbance is presumed to be linked to the inflammatory response involving high levels of pro-inflammatory, pain-dependent cytokines in rotator cuff pathologies, along with oxidative stress involving the muscle and connective tissue cells in the glenohumeral joint. Another theory suggests that sleep disorders may trigger inflammatory pathways, such as those involving nuclear factor- $\kappa$ B, that will lead to the exacerbation of existing inflammatory diseases.<sup>29,30</sup> The inflammation and healing process progresses to a peak at week 6,<sup>31</sup> and possibly contributes to a vicious cycle fuelled by a lack of sleep due to pain, plus dysregulation of shoulder inflammation. Therefore, improving sleep disorders may lead to the improved regulation of these inflammatory pathways.<sup>32</sup> Another mechanism suggests that melatonin may be a mediator of night pain in rotator cuff pathologies.<sup>33</sup>

Clinical guidelines set by the American Physical Therapy Association (APTA) indicate that sleeping disorders are the most common and expected manifestation among patients with adhesive capsulitis.<sup>34</sup> Moreover, a decrease in QoL, in addition to higher rates of depression and anxiety, has been shown in patients with adhesive capsulitis, along with sleep efficacy disturbances.<sup>35</sup> Another study emphasized that sleep disorders secondary to shoulder pain

or discomfort have a negative effect on our QoL and may cause depression and anxiety disorders.<sup>36</sup> All of these associations shed light on the importance of relieving pain and thus improving sleep, as part of a major QoL improvement and a pillar of the bio-psycho-social model in patients with adhesive capsulitis.

The present study has several limitations, one of which is the relatively small number of participants and a disproportion between the subgroups characterized by specific pathologies. In addition, the measurement of sleep disorders was conducted subjectively through direct reporting of the participants, and not through quantitative, objective device measurements. The ISI scale is a subjective tool and as such does not guarantee precise reflection. Finally, in the current study, no matching was conducted between the groups based on demographic variables and the participants were not sampled in a probabilistic manner. This issue may explain the significant differences in age and BMI between the groups. Accordingly, future studies using objective measurements are needed to neutralize environmental influences and demographic variables that may have affected the results. Nevertheless, the present study demonstrates that patients with shoulder pathologies, such as adhesive capsulitis, and partial and complete tears of the rotator cuff, have a relative risk of 4.86 for sleep disorders. A shorter duration of pathology and comorbidities may predict the severity of sleep disorders in patients suffering from shoulder pathologies. Future studies on the subject are required in order to identify patients prone to developing sleep disorders.

#### **Author contributions**

NB – Conception and design; data acquisition, analysis and interpretation; article drafting; final approval

ED – Data analysis and interpretation; article revision; final approval



BR – Data acquisition; article revision; final approval

NR – Conception and design; data acquisition; article revision; final approval

GR – Conception and design; data acquisition; article revision; final approval

All authors read and approved the final manuscript


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The authors declare that there is no conflict of interest

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