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A Survey of Military Patients' Perceptions of Quality and Quantity of Sleep Before and After Endodontic Procedures and the Impact of Sleep Upon Perceived Pain Associated With Endodontic Treatment

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Introduction

The link between poor sleep quality and perceived pain has been studied in a multitude of medical areas. The association between the two is complicated. Both sleep and pain are required at the most fundamental level for human survival. Yet degraded sleep systems and the existence of pain can have a profound impact on a person's daily quality of life.

As dentists and endodontists, one of our daily life's mission is to help patients in pain. Dental care or even a dental office visit can sometimes be so fear-producing in some patients that they avoid dental care until pain becomes extreme or an emergency. Obviously proper pain management is advantageous for the patient and the clinician. Furthermore, chronic pain and insomnia are separately estimated to cost the US economy well over \$70 billion per annum in direct and indirect costs.² Endodontists in the military setting serve a unique patient population in terms of pain and rest. Soldiers have nonstandard jobs with a high level of physicality and, sometimes, physical danger. They can be given duties which preclude normal sleep and rest hours. Furthermore, their function is directly linked to the national defense; therefore, patient wellness is also an aspect of military readiness and national security. For the military endodontist, a better understanding of how pain and sleep interconnect may help the practitioner get Soldiers back on mission faster.

Several studies have shown a connection between pain and sleep quality. Commonly, the phrase bi-directional relationship is used to describe the association between sleep and pain. That is, poor quality sleep seems to be associated with increased pain perceived by patients. In turn, increased pain is associated with poor quality sleep.¹ In general, this bi-directional relationship is born out in a study by Klasser surveying the relationship of pain and sleep, almost 60% of respondents who reported pain problems also had a sleep problems, and 70% of respondents who reported a sleep problems also had a pain problems.⁴ A study by Tang et al conducted on adult pain clinic patients experiencing a wide range of chronic pain etiologies self-reported that sleep quality was an efficient and reliable predictor of next-day pain reports.¹⁴

Clearly there is an association between sleep and pain. Several studies have found an association on the one arm or the pain-sleep connection; pain causing poorer quality of sleep. Smith et al reported approximately 50%-88% of chronic pain sufferers complaining of sleep disturbances² and Koffel et al reported that more than 50% of patients of pain clinics present with some symptoms of insomnia.⁹ In one study, chronic pain patients are 18 times more likely to meet the criteria for the clinical diagnosis of

insomnia.¹⁰ In another study of patients with chronic pain from osteoarthritis, 50% reported symptoms of insomnia with increased pain levels being associated with poorer sleep quality. When pain was reduced, a significant number of the patients found improved sleep quality.²⁰

Looking at the bi-directional relationship between sleep and pain in the alternative way, there appears to be a corollary between sleep quality and perceived pain. Several studies have found an association between poor quality sleep and increased pain perceived, and several studies suggest that sleep is a more consistent predictor of pain versus pain being a predictor of poor sleep.^{5,9} In a randomized trial by Koffel et al, patients with musculoskeletal or more generalized pain of duration for at least 3 months, sleep was a strong predictor in changes of pain. Early improvement of sleep resulted in predictable improvement of pain and visa versa. In a telephone study conducted in 2008, Edwards et al reported that a previous night's quality of sleep was associated as a highly significant factor in the subsequent day's pain frequency, and that individuals reporting less than 6 hours of sleep also had more frequent pain complaints the following day.¹⁸ In a study by Drewes et al, rheumatoid arthritis patients reporting poor sleep quality were associated with an increase in joint pain severity 6 months later.¹¹ In a Danish study in 2005, there was a reported increased risk of patients developing chronic headaches 12 years in the future if insomnia symptoms were present at the base time.¹² Another study reported women with frequent sleep problems are at an increased risk of developing fibromyalgia.¹³ In a laboratory setting, studies have indicated that sleep deprivation produces hyperalgesic responses in humans whether that was total sleep deprivation or some variation or partial sleep deprivation.^{15,16,17} In fact, it has even been reported that individuals who suffer from poor sleep are at an elevated risk for development of pain complaints even in the long-term, up to 28 years.¹⁸ Finan et al found that quality sleep was associated with improving the long-term prognosis of individuals with chronic headache or neuromusculoskeletal pain.⁸

While this bi-directional relationship between sleep and pain has been illustrated well in medical research, it has only been partly evaluated in dental literature. Orofacial pain, a common chief complaint for dental professionals to manage, has been associated with sleep disturbances. In a cross-sectional population based study of 4000 individuals, patients with either chronic or acute orofacial pain were at an increased risk of sleep disturbances and pain related awakenings during sleep.¹⁸ In a study of Temporal Mandibular Disorder (TMD) patients, poor sleep was associated with decreased pain inhibitory function, a possible mechanism explaining the increased hyperalgesia in sleep deprived patients.¹⁸ As dentists and endodontists regularly dealing with acute pain and often causing acute injuries, it is interesting to note one study reported the development of symptoms of insomnia resulting from an acute injury associated with increased post injury pain.²³ This might indicate the bi-directional relationship can be exacerbated with dental procedures which often cause short term pain for patients.

These are just a few of the multitude of research conducted on the relationship between sleep and pain. This bi-directional relationship is complicated and can have a profound impact on a patient's daily quality of life. The repercussions can penetrate into

all aspects of life, affecting professional and personal health. Certainly this is a concern for a patient population comprised of military members.

The Biological Mechanism behind this Connection

There is a biological basis for the bi-directional relationship between sleep and pain. Many structures in the brain are associated with nociception and the homeostasis of sleep. The mesencephalic periaqueductal gray plays a critical role in autonomic functions and is a primary control center for descending pain modulation.²⁶ It is known to modulate sleep states and regulate nociception. Similarly, the thalamus is a key structure actively associated with arousal and synchronization of the cortex during sleep and processing of nociceptive stimuli before transmitting information to the cortex.² Chronic pain has been reported to cause atrophy in key parts of the brain involved in the pain-inhibitory pathways, such as the prefrontal cortex, resulting in decreased modulation of the limbic system and alteration of the inhibitory pain pathways.²⁴ Because of these connections, it is possible that sleep deprivation may impair functioning of endogenous pain-inhibitory systems or that acute or chronic pain may impair the modulation of sleep.

Chronic poor-quality sleep may cause sensitization and habituation resulting in altered pain processing and increased pain sensitivity.³ In one study by Arima et al, subjects artificially induced to have significant sleep disturbances showed an increased trend toward decreased pain pressure thresholds.²⁵ Additionally, as part of the nociceptive system, proinflammatory and anti-inflammatory signaling molecules play a key role. Chronic pain patients have been reported to have higher levels of pro-inflammatory mediators such as IL-1b and TNF-alpha, both of which play a role in sleep regulation and homeostasis. These higher levels may cause an increase in sleep fragmentation or alter rapid eye movement (REM) and non-REM sleep. Alteration of REM sleep cycle could result in decreased levels of serotonin, an important neurotransmitter involved in the descending pain modulation pathway. Decreased levels of serotonin caused by sleep deprivation or disturbances, could result in decreased activity of the inhibitory pain pathways and/or enhanced central sensitization. Interestingly, the thalamus secretes, amongst others, a neurotransmitter called gamma-aminobutyric acid (GABA) which is involved in the sleep-wake cycle. A barrage of nociceptive input, such as is associated with chronic pain, might cause a decrease in GABA secretion with an inhibitory effect on the thalamus, causing hyperarousal and sleep disturbances.⁴

Even prostaglandins, the classic inflammatory marker observed in increased levels in patients with pain, has been shown to have a modulatory effect on sleep. Acute administration of aspirin, possibly at levels recommended for dental pain such as the recommended daily dose, inhibits prostaglandin production and has been shown to impact sleep quality. Additionally, sleep deprivation has been shown to increase prostaglandin levels, which are associated with greater pain reporting from patients, further illustrating the complex connection between sleep and pain.⁶

The purpose of this study was to determine whether a patient's quality and quantity of sleep had any impact upon the patient's perceived pain before, during, and after endodontic treatment. Additionally, we investigated whether a patient's dental pain

impacted their sleep the night before or after their appointment. The null hypothesis is that pain would have no significant effects on sleep before or after the patient's endodontic treatment and sleep would have no significant effect of the patient's perceived pain before, during or after the endodontic treatment.

Materials and Methods

Data for this survey were collected using anonymous short-form online surveys distributed via text message. Data collection began in August 2021 and ended in October of 2021. All patients seen at the Ft Bragg Endodontic Clinic during this time, including active duty military members and retirees, who were seen for an endodontic treatment appointment were included. Patients seen for evaluation or post-operative care appointments were not selected.

Although, a total of 101 completed surveys were received during the data collection period. Two surveys were excluded from the analysis as they were largely incomplete and an additional 6 surveys were removed due to being duplicate survey entries. This was determined by examining the demographic profile as well as the IP address from which the survey was sent. In cases of repeated surveys, only the first completed survey was retained for analysis.

The survey instrument included demographic questions regarding participant age, gender, race/ethnicity, and rank. Respondents were also questioned about their typical sleep habits and whether their sleep was affected by dental pain. Finally, respondents were asked to rate the highest level of dental pain experienced on a scale of 0 to 4, with 0 being an absence of pain and 4 representing severe pain. Respondents were asked to rate the highest level of pain they recalled feeling immediately before the appointment, during the appointment, and after the appointment (Table 2).

Descriptive statistics are presented to describe the frequency of responses. The normality of data distributions for continuous variables was assessed using the Shapiro-Wilk test. Medians with associated interquartile ranges (IQR) were used to summarize non-normally distributed continuous data (participant age, typical number of hours slept per night, and time to complete the survey). Chi-square and Mann-Whitney U tests were used for pairwise comparisons. The Kruskal-Wallis test was used to assess differences in pain between race/ethnicity categories. In cases of multiple comparisons, the Bonferroni adjustment was made to the declared alpha level. Significance was declared at $P < 0.05$ for all tests. All data were analyzed by using SPSS version 25.0 (SPSS, Chicago, IL).

Table 2. Survey Questions

| | |
|--|---|
| What is your age? | [Enter number] |
| What is your sex? | <input type="checkbox"/> M <input type="checkbox"/> F <input type="checkbox"/> Prefer not to answer |
| What is your race/ethnicity? | <input type="checkbox"/> white <input type="checkbox"/> Hispanic/Latino <input type="checkbox"/> Black/African-American <input type="checkbox"/> Native American/American Indian <input type="checkbox"/> Asian/Pacific Islander <input type="checkbox"/> Other <input type="checkbox"/> Prefer not to answer |
| Officer or Enlisted? | <input type="checkbox"/> Warrant Officer <input type="checkbox"/> Company Grade Officer (O-1 to O 3) <input type="checkbox"/> Field Grade Officer (O-4 and above) <input type="checkbox"/> Junior Enlisted (E-1- E-4) <input type="checkbox"/> NCO (E-5 and above) |
| Was this your first root canal appointment or was this continuing treatment? | <input type="checkbox"/> This was my first appointment <input type="checkbox"/> This was a follow-on appointment |
| How many hours of sleep do you usually get on an average night? | [enter number] |
| How much sleep did you get the night before this root canal appointment? | <input type="checkbox"/> <6hrs <input type="checkbox"/> 6-9hrs <input type="checkbox"/> >9hrs |
| Did you feel well rested for this root canal appointment? | <input type="checkbox"/> I felt completely rested <input type="checkbox"/> I felt moderately rested <input type="checkbox"/> I was tired, my dental pain impacted my sleep <input type="checkbox"/> I was tired, but my dental pain did not impact my sleep |
| Did dental pain impact your sleep AFTER your appointment? | <input type="checkbox"/> No, my sleep was not impacted by dental pain <input type="checkbox"/> Yes, my sleep was impacted by dental pain |
| For the remaining questions, on a scale of 0-14, with 0 being no pain and 4 being severe pain, please answer the following questions: | |
| How much pain were you in right before your dental appointment? | <input type="checkbox"/> 0 (no pain) <input type="checkbox"/> 2 (moderate pain) <input type="checkbox"/> 4 (severe pain) |
| What was the highest level of pain experienced during the appointment? | |
| What was the highest level of pain experienced after your dental appointment? | |

Results

The median completion time for the 93 surveys included in this analysis was 94sec (IQR 59-126). No differences in gender, race/ethnicity, reported pain levels were found based on survey completion time (all $P > 0.05$). However, a positive correlation was observed between age and completion time, $r(78) = 0.29, P = 0.01$). The median age of those in the bottom quartile of completion time was 26 years compared to 41years in the top quartile.

Table 1 details the demographic characteristics of the sample. The median age of the respondents was 33 years (IQR 25-42). The sample consisted of 72.8% (n = 67) men and 27.2% (n = 25) women. The majority of the sample identified as being white 45.6% (n = 41), with only 26.7% (n=26.7) identifying as black, 11.1% (n=10) Hispanic, and 16.7% (n=15) other racial/ethnicities, including multiracial respondents. For nearly half of the sample, the appointment in question was the initial root canal appointment (n=47; 50.5%) while the other half (n=46; 49.5%) presented for follow-up care.

Table 1. Respondent Characteristics

| Characteristic | n | % |
|-------------------------------------|----|------|
| Gender ^a | | |
| Men | 67 | 72.8 |
| Women | 25 | 27.2 |
| Race/Ethnicity ^b | | |
| White | 41 | 45.6 |
| Black | 24 | 26.7 |
| Hispanic | 10 | 11.1 |
| Other, Including Multiracial | 15 | 16.7 |
| Rank ^c | | |
| Officer | 21 | 22.8 |
| Enlisted (E1-E4) | 33 | 35.9 |
| Enlisted (E5+ and Warrant Officers) | 38 | 41.3 |
| Apt Type | | |
| First appointment | 47 | 50.5 |
| Follow-on appointment | 46 | 49.5 |

^a N=92 due to non-response; ^b N=90, due to non-response; ^c N=92 due to non-response

The median amount of typical sleep reported by respondents was 6 hours (IQR 5-7). This closely reflected the self-reported sleep received the night before the root canal appointment. Half of the participants (n=52; 55.9%) reported sleeping less than 6 hours the night before the appointment. Most of the remaining participants (n=40; 43.0%) reported sleeping between 6 and 9 hours, with only 1 individual (1.1%) reporting more than 9 hours of sleep the night prior to the appointment. Despite the sample on the whole reporting less than the recommended 8 hours of sleep per night, the majority of respondents indicated that they felt rested for the appointment (n=68; 74.0%) and that dental pain did not impact sleep after the appointment (n=76; 81.7%).

When questioned about the highest level of pain experienced before, during and after the root canal appointment, the reported levels were markedly consistent with the median for all 3 time points being 2 on a 0 to 4 scale. Perceived maximum pain levels after the appointment were positively correlated with highest pain levels prior to the appointment, $r(89) = 0.23$, $P = 0.03$. No relationship was found between dental pain at any time point and either age or typical sleep duration (all $P > 0.05$). Similarly, results

failed to indicate a significant relationship between highest level of reported pain at any of the time points and either the respondent's gender or race/ethnicity.

Discussion

The majority of respondents indicated that they felt rested for their endodontic appointment and that dental pain did not impact sleep before or after the endodontic appointment. Additionally, reported perceived maximum pain levels were markedly consistent with the median for all 3 time points being 2 on a 0 to 4 scale. Therefore, the null hypothesis was accepted.

Perceived maximum pain levels after the appointment were positively correlated with highest pain levels prior to the appointment. This is consistent with previous literature reports which found an association between patients reporting higher pre-operative pain also reporting higher post-operative pain.^{27,28} This finding is unsurprising as much of the classical endodontic literature has found that pre-operative pain is a risk factor for post-operative pain.²⁹

The results failed to indicate a significant relationship between highest level of reported pain at any of the time points and the respondent's gender. This is inconsistent with some reported literature, which has reported on an association with women experiencing more severe pain versus men.^{30,31} However, this study was conducted in a military environment and the demographics of the surveys reflect this disproportionate gender sampling as shown that only 27% of the sampled population was female.

There are several limitations of the present study. All pain and sleep quality and quantity data were recalled at one timepoint in one survey collection report from the patient. The survey link was sent via a total of two text message requests. One text was sent at approximately 24 hours after the patient's endodontic appointment, and a second follow-on request was sent at approximately 48 hours after the patient's endodontic appointment. The nature of this request depends on individuals being able to recall not only how many hours of sleep they had the night before their endodontic appointment, the quality of that sleep, and the pain level felt at certain time points in the past 48-72 hours. This, of course, adds a confounding element to the data, as patients' recollection of past sleeping and pain details are not infallible. It's possible that the current pain level felt by the patient at the time they were answering the survey, which was post-treatment, may have influenced how a patient remembered his/her pain before the appointment. Since pain levels are generally lower post-endodontic treatment, it stands to reason that at the time the patients were answering the survey, they were probably already in less pain than before treatment.

The military population is generally healthy, with a low incidence of chronic diseases such as hypertension or osteoarthritis which are prevalent in the American population at large. Data were collected from a small sample size, the majority of which were healthy men, and therefore may not be applicable to other populations. In fact, it has been reported that both chronic pain and sleep disturbances share comorbidities such as obesity, Diabetes Mellitus Type 2 and depression.⁴ These factors were beyond the scope of this study and not applicable in a generally healthy military population as studied here.

Half of collected data points were from follow-on endodontic treatment appointments; these teeth were already accessed and instrumented to some degree. Generally, due to the nature of endodontic treatment, patients are more likely to have pain before initial endodontic treatment and, naturally, less pain on the second visit, after the initial cleaning and shaping. It would stand to reason, that this could therefore influence the results and significant associations in this study.

As these results are drawn from a very specific military population, and due to the reasons stated above, they may not be applicable to other dental populations. It is recommended that further studies with longer data collection periods be conducted.

While we have discussed several possible mechanisms explaining the bi-directional link between sleep and pain that have been reported in the literature, in reality, this complex relationship is probably affected by multiple neurobiological, psychological and social-cultural mechanisms. Challenges when studying any subjective topic such as pain perception abound. Subjective feelings are just that and one person's severe pain level is not equal to another's. Additionally, many sleep-pain studies are retrospective or prospective, not randomized controlled trials, have small sample sizes, short follow up timeframes, rely on patient compliance and adherence to the study protocol. Therefore it is difficult to study this complex topic. While this study did not find any significant associations between the quality and quantity of sleep of a patient and their perceived pain level, it is an important initial study, and to the best of these authors' knowledge the only of its kind on endodontic patients' pain and sleep associations.

Conclusions

The majority of respondents indicated that they felt rested for their endodontic appointment and that dental pain did not impact sleep before or after the endodontic appointment. The reported perceived maximum pain levels were consistent with the median for all 3 time points and not associated with poorer quality or quantity of sleep either before or after the endodontic treatment appointment.

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