The Influence of Sleep Quality on Chronic Pain

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ABSTRACT

Sleep is an essential physiological process that performs the maintenance of several mechanisms inherent to human homeostasis, being considered a healthy sleep, one that has quality and quantity determined to maintain a state of wakefulness during the day. According to the World Health Organization, 30% of the world population has chronic pain. Thus, the objective of this study was to verify the relationship between quality of sleep and chronic pain. This is therefore a field research, carried out via an online form, on pain characteristics and quality of sleep in individuals with chronic pain. The results achieved showed 42 valid answers, with individuals with a mean age of 34.25 (±11.30) years. The average intensity of pain was 4.70 (±2.09), and the quality of sleep was classified as good in 52.28% of the volunteers, although the majority of them slept less than 7 hours per night. Statistically the worse the quality of sleep, the greater the intensity of pain p=0.01, the worse the quality of sleep, the greater the feeling of not having rested, in which p= 0.03 and the worse the quality of sleep, the greater the sleepiness during the day with p= 0.007. We conclude that the greater the intensity of pain, the worse the quality of sleep of the individuals.

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Classification: WB176

Language: English

Great Britain Journals Press

LJP Copyright ID: 392871

London Journal of Medical and Health Research

Volume 23 | Issue 3 | Compilation 1.0

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ABSTRACT

Sleep is an essential physiological process that performs the maintenance of several mechanisms inherent to human homeostasis, being considered a healthy sleep, one that has quality and quantity determined to maintain a state of wakefulness during the day. According to the World Health Organization, 30% of the world population has chronic pain. Thus, the objective of this study was to verify the relationship between quality of sleep and chronic pain. This is therefore a field research, carried out via an online form, on pain characteristics and quality of sleep in individuals with chronic pain. The results achieved showed 42 valid answers, with individuals with a mean age of 34.25 (±11.30) years. The average intensity of pain was 4.70 (±2.09), and the quality of sleep was classified as good in 52.28% of the volunteers, although the majority of them slept less than 7 hours per night. Statistically the worse the quality of sleep, the greater the intensity of pain p=0.01, the worse the quality of sleep, the greater the feeling of not having rested, in which p= 0.03 and the worse the quality of sleep, the greater the sleepiness during the day with p= 0.007. We conclude that the greater the intensity of pain, the worse the quality of sleep of the individuals.

Keywords: sleep, circadian cycle, chronic pain.

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I. INTRODUCTION

Sleep is an essential physiological process that performs the maintenance of several mechanisms inherent to human homeostasis, playing an active role in both cognition and health [1,2].

Sleep is typified in humans by 5 stages that are differentiated by the presence or absence of rapid eye movements (rapid eye movement: REM; no rapid eye movement: N-REM), in addition to various physiological variables, such as the cardiorespiratory pattern and muscle tone.

Reactivity to auditory, visual, tactile and painful stimuli is reduced or abolished in relation to vigil, particularly in deep sleep phases. A predictable sleep cycle is about 90 minutes, which traces the variation between the 4 stages from N-REM sleep to REM sleep [3].

The ideal average sleep time is 7 to 8 hours per night, however, the structure of sleep varies between individuals and their age therefore, a healthy sleep is one that has quality and quantity determined to maintain a state of wakefulness during the day [4].

The capability of the individual to adjust his/her sleep and wakefulness cycle is oriented by several external elements such as luminosity, temperature, sounds, as well as by the neurochemical bio-rhythm that comes with the circadian variations, with specific changes in body temperature and in the secretion of several hormones and neurotransmitters, related to different stages of sleep and wakefulness [3].

The supraoptic nucleus receives light impulses from the optic nerve stimulating the pineal gland to secrete melatonin, an essential neuro-hormone in the chronobiology of the sleep-wake cycle, having its peak in the first hours of the night and hence considered as one of the "gates" for entering sleep, thus, if the individual forces the

state of wakefulness fighting against sleep he/she loses the propitious moment to enter the state of sleep [3].

A range of evidences suggests that sleep, or the lack of it, may interfere with certain brain functions such as learning, memory and the regulation of endocrine and autonomic secretion According to the World Health Organisation (WHO), four out of ten people do not get good quality sleep, and sensitivity to pain can be modulated by the quality and quantity of sleeping hours [5,6].

According to IASP [7] (International Association for the Study of Pain) pain is defined as: "an unpleasant sensory and emotional experience associated, or similar to that associated, with a real or potential tissue injury", being also considered a subjective experience, influenced in various degrees by biological, psychological and social factors. The IASP recommends chronic pain as that one lasting more than six months, of continuous or recurrent condition (three episodes in three months).

Due to its long duration, chronic pain becomes no longer a warning sign, losing the ability to maintain homeostasis, leading to suffering and functional impairment, which progressively incapacitates the individual generating socioeconomic costs. More than one third of the Brazilian population deems that chronic pain compromises the usual activities and more than three quarters consider that chronic pain is limiting for recreational activities, social and family relationships [8].

The WHO estimates that an average of 30% of the global population suffers with chronic pain. In Brazil, this is equivalent to 60 million Brazilians.

Around 50% of those affected by the problem face routine impairment, such as absence and inability to work or even to perform the simplest tasks, estimates the Brazilian Society for the Study of Pain (SBED). Not surprisingly, 75% to 80% of medical attention in public services are motivated by complaints of pain, according to international epidemiological data, informs the Ministry of Health. [9]

The biopsychosocial approach claims that the experience of pain is determined by the interaction between biological factors including nerve pathways as well as biochemical processes, psychological factors covering emotions, thoughts, beliefs, expectations and attributions, and finally, social factors ranging from interpersonal interactions and sociocultural expectations [10].

Therefore, the aims of this study were to investigate whether there is a relationship between the quality of sleep and chronic pain, specifically to identify factors that may commonly impair sleep and pain concomitantly.

II. METHODS

This research is a field research approved by the Research Ethics Committee by the number CAAE: 58271822.0.0000.5386, in which a survey of data was carried out through an adapted form on pain characteristics and quality of sleep, which was based on the Pittsburgh form regarding sleep questions. The form was applied via Google Forms https://docs.google.com/forms/d/e/1FAIpQLSc8wwFfhe9yPLX07KipdbV371_W6Vz88IrsMuWhea8UukXnCg/view form), together with the Informed Consent Form (ICF), through social networks (Instagram, Facebook and WhatsApp).

The inclusion criteria included individuals over legal age suffering from chronic pain; and the exclusion criteria involved the non-agreement with the ICF, incomplete or improper completion of the form and individuals taking sleeping medication. There was no limit number of participants or geographical area delimitation.

Data collection was performed between June and August 2022 and subsequently data analysis was performed using Microsoft Windows 10 Excel spreadsheet and SPSS 22 software with ANOVA method considering significant results with $p \leq 0.05$.

III. RESULTS

General data

The research resulted in 101 responses given to the form, however, 59 participants were excluded, 07 of these did not present pain, 34 did not

answer any question related to sleep and 18 in which the pain does not fit chronic pain, which would compromise the objectives of this study.

Thus, 42 participants composed the present results, being 27 women (64.29%) and 15 men (35.71%).

The mean age of the participants was 34.25 years (±11.30). The high standard deviation is explained by the great discrepancy of age, in which the study counted on volunteers from 19 to 68 years old.

The mean age of women was 34.25 years (±11.30) and men 34.77 years (±11.30).

Physical activity was practiced by 57.14% of the volunteers (n=24), 41.66% of whom were female (n=10) and 58.33% male (n=14), and 42.86% (n=18) did not practice any type of physical activity, of whom 94.44% (n=17) were female and 5.55% (n=1) male.

Among the volunteers who practiced physical activity, three groups were defined, where group "A" defined muscle strengthening, representing 37.5% of participants (n=9), group "B" for those who practiced only aerobic activity, represented by 16.66% (n=4) of volunteers and group "C" for individuals who practiced both modalities of group A and B, consisting in this group 45.83% (n=11).

In terms of frequency of physical activity, it was diverse, from 2 to 6 times a week, with the following results: 2x=12.5% (n=3), 3x=29.16% (n=7), 4x =12.5%(n=3), 5x= 33.33% (n=8) and 6x = 12.5% (n=3).

The preferred times for training were divided into morning with 29.16% (n_=7), afternoon with 16.66% (n_=4), night with 45.83% (n_=11), and 8.33% (n_=2) of the volunteers trains at various times according to their availability.

It is noteworthy that none of the volunteers worked at night and slept during the day.

Pain Data

Regarding the characteristics of pain, the classification from 0 to 10 was adopted as a method to assess the intensity, and it was found that the mean pain level of the participants was 4.70 (±2.09). The distribution in the respective levels of pain can be observed in table 1 below.

Table 1: Pain intensity of the participants

Level of Pain 0-10	Number of participants	% Representation
02	06	14,29%
03	08	19,05%
04	05	11,90%
05	08	19,05%
06	03	7,14%
07	06	14,29%
08	04	9,52%
09	01	2,38%
10	01	2,38%

Caption: Left column represents the number of pain reference according to the numeric pain scale (0 to 10), the middle column represents the number of participants corresponding to the intensity of pain classification, and the right column represents the percentage of participants in each level of pain intensity. Source: The author herself.

By using the classification of pain as weak (levels 1 to 3), moderate (levels 4 to 6), strong (levels 7 to 9) and unbearable (level 10), the following results in the level of pain of the volunteers were obtained: weak 33.33% (n=14), moderate 38.09% (n=16), strong 26.19% (n=11) and unbearable 2.38% (n=1).

The interference of this pain in sleep is described by 26.19% (n=11) who reported waking up in the middle of the night due to pain, however, the great majority of volunteers 73.81% (n=31) do not wake up during the night due to pain.

Sleeping Data

A survey of the amount of hours of sleep was carried out by the volunteers, the results are presented in table 2 below:

Table 2: Amount of hours slept per night by the volunteers

Sleeping hours	Quantity of answers	% Representation
4h	1	2,38%
4h30	1	2,38%
5h	2	4,76%
5h30	5	11,90%
6h	12	28,57%
6h30	3	7,14%
7h	9	21,43%
7h30	2	4,76%
8h	4	9,52%
+ de 8h	2	4,76%
Not specified (insomnia)	1	2,38%

Caption: Left column indicates the amount of hours of sleep per night; middle column the amount of volunteers who fit into a certain sleep time and in the right column the percentage of participants for each sleep period. Source: The author herself.

It is highlighted that 59.52% (n=25) of the participants slept less than 7h per night, 26.19% (n=11) slept between 7 and 7h30 and only 14.28% (n=6) slept 8h or more as recommended by the WHO.

When analysing the quality of sleep from the point of view of the volunteers, the following results were obtained: very good sleep 7.14% (n=3), good 52.38% (n=22), bad 33.33% (n=14) and very bad 7.14% (n=3). However, despite the positive rate in reporting sleep quality as good, the feeling of NOT having rested during sleep was expressed by 76.19% (n=32) of the participants with only 23.80% (n=10) of those with the perception of sleep having been restorative.

Another evaluated element was sleepiness on the part of the participants during their daily activities, in which 76.19% (n=32) reported feeling sleepy during their daily activities, while only 23.80% (n=10) reported not feeling sleepy during the day. Only one of the volunteers (2.38%) did not feel sleepy during the day and did not use stimulants for the Central Nervous System.

Regarding the use of these substances, 52.38% (n=22) make use of some type, such as chocolate, tea, ginseng, cinnamon, energy drink and coffee, the latter being used by 90.90% (n=20) of those who use stimulants, and 47.61% (n=20) do not use this class of substances.

Further analysis was carried out on the perception of the volunteer on the quality of sleep and the worsening of pain, in which 64.29% (n=27) stated that whenever they slept badly the next day they reported worsening of the pain, or still, that when the intensity of pain was greater during the day, the quality of sleep was worse, and 35.71% (n=15) of the participants could not make this correlation.

IV. RELATION BETWEEN DATA

In the analysis of the pain of the individuals associated with the quality of sleep, it can be observed in table 3 below, that most of the volunteers refer to good quality sleep, and these fall within the intensity of weak to moderate pain, and as the intensity of pain increases to strong, most refer to poor quality sleep.

In the statistical analysis of these data, it was found that the worse the quality of sleep of the individual, the greater the intensity of pain, with a high degree of significance where p=0.01.

Table 3: Relation between pain level and quality of sleep

Level of pain	Quantity of individuals	Very good sleep	Good Sleep	Bad sleep	Very bad sleep
Weak	14 (33,33%)	3 (21,43%)	9 (64,29%)	2 (14,29%)	----------
Moderate	16 (38,09%)	----------	9 (56,25%)	5 (31,25%)	2 (12,5%)
Strong	11 (27,19%)	----------	3 (27,27%)	7 (63,64%)	1 (9,09%)
Very strong	1 (2,38%)	----------	1 (2,38%)	----------	

Caption: Column on the left refers to the intensity of pain classified as weak, moderate, strong and very strong, followed by the number of volunteers who referred pain in these intensities and subsequently the amount of participants who fit each type of sleep, on a scale from very good to very bad. Source: the author herself.

Table 4 below shows the relationship between sleep quality and the feeling of not having rested after the rest period, and the presence of sleepiness during the day and as a result, it can be seen that the worse the quality of sleep, the greater the feeling of not having rested, where p= 0.03 and the worse the quality of sleep, the greater the sleepiness during the day with p= 0.007.

Table 4: Sleep quality and feeling NOT rested & sleepiness during the day

Sleep Quality	Feeling not rested	Sleepiness during the day
Very good 7,14% (n=3)	Yes = 66,67% (n=1) No = 33,33% (n=2)	Yes = 66,67% (n=1) No = 33,33% (n=2)
Good 52,38% (n=22)	Yes = 63,64% (n=14) No = 36,36% (n=8)	Yes = 72,72% (n=16) No = 63,64% (n=6)
Bad 33,33% (n=14)	Yes =100 % (n=14) No = 0% (n=0)	Yes = 85,71% (n=12) No = 14,29% (n=2)
Very bad 7,14% (n=3)	Yes 100%= (n=3) No = 0% (n=0)	Yes = 100% (n=3) No= 0% (n=3)

Caption: The left column shows the reference of the volunteer regarding his/her quality of sleep, in the middle column the number of volunteers who had the sensation of not having rested during the night and its relation with the level of pain; the right column shows the number of individuals who reported sleepiness during the day. Source: author herself.

Another relation analysed was the practice of physical activity, the schedule of practice and pain intensity. Table 5 below shows that the majority of individuals with intense pain do not practice physical activity. The relationship between physical activity and pain presents a statistical analysis with p≤0.001, proving that sedentary individuals present greater intensities of pain.

Table 5: Pain level and physical activity practice

Pain level	Practice of Physical Activities	Schedule of physical activity
Weak (n=14)	Yes = 78,57% (n=11) No = 21,43% (n=3)	Morning = 36,36% (n=4) Afternoon = 18,18% (n=2) Evening = 45,45% (n=5)
Moderate (n=16)	Yes = 62,5% (n=10) No = 37,5% (n=6)	Morning =20% (n=2) Afternoon = 30% (n=3) Evening = 50% (n=5)

Strong (n=11)	Yes= 27,27% (n=3) No= 72,73% (n=8)	Morning =33,33% (n=1) Afternoon = 33,33% (n=1) Evening= 33,33% (n=1)

Caption: Left column shows the level of pain (weak, moderate or strong), middle column shows the number of individuals who do or do not practice physical activity, and in the right column the time of day that these individuals practice physical activity. Source: The author herself

V. DISCUSSION

It is recommended a total sleep time greater than 7 hours for the population in general, since sleep is responsible for regulating the body's homeostasis, being essential for the cognitive and physiological recovery of individuals [11,12]. In this study, it was observed that 59.52% (n=25) of the volunteers slept less than 7 hours per night, not following the recommended amount of sleeping hours.

Researchers suggest that some lymphokines do promote NREM sleep, such as the tumour necrosis factor alpha (TNF-α) and interleukin-1 (IL-1), which means that these substances can regulate physiological sleep, as well as other molecules from the immune system. The main symptom in individuals with sleeping disorders is excessive daytime sleepiness, and these normally present with elevated interleukin-6 (IL-6) in the blood [13-15]. In this scenario, it was found that 76.19% (n=32) of the volunteers in this study reported feeling sleepy during the day. It is worth mentioning that no blood analysis was performed on the volunteers.

While healthy sleep facilitates immune functions, impaired quality or quantity of sleep can result in a low-grade inflammatory response, the response as a consequence of sleep deprivation includes increased levels of nitric oxide (NO), prostaglandin E2(PGE2) and IL-6, and possibly mediated by glia cells [16].

Sleep deprivation imparts a low-grade inflammatory response, leading to increased pain sensitivity, as observed in individuals with chronic pain [16], in which the subjects of this study fit.

Nowadays, it is known that the treatment of chronic pain is complex and, in order to be effective, a multidisciplinary approach is required, with physical exercises being a key part of the treatment, since physical activity, besides being indicated as a non-pharmacological intervention with positive results for the treatment of chronic pain, is an accessible therapy from the economic point of view [17-19].

It is observed in this study that 51.4% (n=24) of the volunteers practices some type of physical activity, and even so, they are affected by chronic pain. Although the clinical benefits of exercise in reducing the intensity of chronic pain are highlighted, the physiological effects involved are still unclear; sometimes the analgesic effect is contradictory [20]. One of the most described hypotheses to explain this increase in pain threshold - comparing athletes or active and sedentary people - is the influence of the practice of activity and/or physical exercise on endogenous mechanisms, which leads to the opioids release [21,22].

Although the majority of volunteers in this research practiced physical activity, pain was present in all volunteers, it was also observed that 33.33% (n=14) of the volunteers had pain of low intensity, in which 78.57% (n=11) did some activity, 38.09% (n=16) presented pain of moderate intensity, of these, 62.50% (n=10) practiced exercises, and 27.19% (n=11) reported pain of strong intensity, where only 27.27% (n=3) had physical activity in their routine of life.

Researches elucidate the findings of this study, since they concluded in their studies that physical exercises can be beneficial in reducing the intensity of chronic pain and in general aspects of quality and physical and mental health [23-25].

Souza [26] adds to the authors above that exercise does not need to be of high intensity to have an effect on pain, concluding his research by affirming that moderate intensity aerobic exercise for more than 10 minutes is able to activate endogenous mechanisms of pain control in healthy individuals.

In a study conducted among elite athletes describes that behavioural factors related to the athlete's routine seem to be more important for injury and pain, singling out sleep, which includes the amount of hours slept and the quality of sleep [27]. Other studies [28,29] reported that sleep deprivation leads to a reduction in the production of growth hormones (GH) and testosterone, as well as an increase in cortisol, thus directly affecting the organism's homeostasis as defined by Hirshkowitz 12, a factor to be considered in the volunteers of this study.

The time of doing physical activity in this study, according to the participants, was predominantly during the evening, with 45.83% (n=11) training at this time of day. Stutz and collaborators [30] stated in their study that the exercises practiced at evening do not interfere negatively in sleep, as long as the time of exercise is up to one hour before bedtime and high intensity. Wendt et al [31] showed divergent results, in which the practice of evening physical activity resulted in a negative effect on sleep, not depending on the intensity, but in relation to daytime physical activity, which showed positive results on sleep·

Kraemer [32] reports in a study that although the neuroendocrine adaptations seem minimal, the hormonal response depends on the intensity, volume, involvement of muscle mass, rest intervals and frequency, where high volume and moderate to high intensity exercises tend to produce higher elevations of anabolic hormones such as GH and testosterone, but also of cortisol, which is a catabolic hormone involved in the sleep process. Other researchers [33-36] corroborate with Kraemer [32], that the relation of physical activity and its duration/intensity with the level of cortisol, in which, when it is performed with a high level of effort and/or stress, either by intensity or duration, there is an increase in the level of cortisol. Upon physical exercise there is secretion by the hypothalamus of the hormone that releases corticotrophin, activating the pituitary gland, where it stimulates the release of adrenocorticotropin, which stimulates the release of cortisol by the adrenal cortex. In the present study, the volume/intensity of the physical activity performed by the volunteers was not evaluated, but its close relationship with the results presented here is assumed.

The NREM sleep is regarded as the restorative sleep phase; authors have reported that the increase in cortisol at night reduces the REM sleep phase and increases the NREM phase, which is explained by a biphasic effect of cortisol, in which up to a certain level, it favours the REM phase, but when it is too high, it inhibits it [37]. In the present study, it was verified that 76.19% (n=32) of the volunteers reported waking up feeling tired, even though the majority, 52.38% (n=22) reported a good quality of sleep, which makes us wonder about the connection of cortisol levels among these volunteers.

Another factor to be considered is that 52.38% (n=22) of the participants in this study use some kind of stimulant substance during the day, especially coffee, used by 90.90% (n=20 of the 22 who take stimulants). Caffeine activates the stress axis, raising glucocorticoids and catecholamines[38].

The effect of caffeine on glucocorticoid regulation has, therefore, the potential to alter circadian rhythms and interact with stress[39], which can be a factor related to changes in the quality of sleep, as well as associated with chronic pain in the participants of this study, since 64.29% (n=27) of them described that after a bad night's sleep, their pain worsened.

Hence, the relationship between sleep disturbance and chronic pain would probably be best characterised as a reciprocal vicious circle, with pain contributing to sleep disturbance and also contributing to increased pain sensitivity[40].

Araújo and collaborators[6] corroborate with Smith[40] stating that reduced sleep time increases the response to pain and chronic pain conditions are capable of altering the sleep pattern.

VI. CONCLUSION

Sleep has an important function in the balance of the organism, and a non-restorative sleep or sleep of less than seven hours can cause an inflammatory response, increasing sensitivity to pain. Most participants in this study slept less than seven hours, not following the WHO recommendations, and although most of the

volunteers classified their sleep as of good quality, it was found that 76.19% of the individuals in this study reported waking up with the sensation of not having rested. Tiredness upon waking up, as well as sleepiness during the day, was more frequent in the volunteers with greater intensity of pain, being an inconsistency when they report having good quality sleep.

On the other hand, the practice of physical activity is being shown as one of the main and most important forms of treatment in the control of chronic pain, since it can trigger the release of endogenous opioids that act in the pain sensitivity control. Most participants practiced physical activity and reported weaker pains when compared to sedentary individuals, whose pain had a greater intensity, indicating that exercise is a beneficial factor, however, the intensity of physical activity may be related to the inflammatory index of the body and the release of substances such as cortisol and IL-6 in the organism. Added to other factors such as coffee, which is frequent in the routine of the volunteers of this study, the quantity of circulating inflammatory hormones and cytokines in the organism may be directly linked to cases of chronic pain, as well as, associated to poor quality of sleep, with the conclusion being that the greater the intensity of pain, the worse the quality of sleep. Nevertheless, new studies are necessary, in which it is possible to measure the intensity of exercises, the quantity of circulating hormones and cytokines for more complete results in the population that suffers with chronic pain.

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