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# Physical and Psychological Stress and Sleep Efficiency before and after Introducing a New Sleep Surface

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## Abstract

**Background:** It has been long assumed that stress interferes with sleep, but less has been attributed to the converse of poor sleep contributing to stress.

**Study question:** Can an older sleep surface contribute to poor sleep and thus, stress and will a new sleep surface provide better sleep, thus less stress.

**Methods:** Forty-six participants rated physical and psychological signs of stress and sleep efficiency for three weeks while sleeping in their own beds. Following baseline measures participants' beds were replaced by new, unmarked beds and they again rated their stress and sleep efficiency.

**Results:** Average age of participants' bed was 11.27 yrs. Physical and psychological signs of stress were reduced significantly ($p<0.01$) from pre- to post-assessments. Similarly, sleep efficiency improved significantly ($p<0.01$) between pre- and post-assessments.

**Conclusions:** Replacing an older mattress that may have lost adequate support and comfort may result in a better night's sleep thereby reducing stress brought on by a lack of sleep. It was suggested that a simple principal step in acquiring better sleep is to consider a new sleep surface rather than to opt for pharmaceuticals to achieve better sleep.

**Keywords:** Sleep; Bed; Mattress; Quality; Stress

## Introduction

The National Sleep Foundation suggest that the amount of sleep varies with age, lifestyles, and health status and indicate that as we grow from infancy to adult hood we require less and less sleep [1]. Additionally, the NSF suggests that the average adult needs between seven and nine hours of sleep per night. However, in 2013 it was estimated that Americans average 6.8 hours per night and that 40% of Americans average six or less hours per night [2]. Sleep deprived individuals exhibit impairment in several areas such as operating machinery, [3] lack of focus, [4] sustained attention, reaction time, and cognitive processing speed [5]. These impairments contribute to a high degree in loss of work productivity and workplace injury [1,6-11]. Recently, researchers have suggested a strong and complex link between lack of sufficient sleep and cardiovascular health [12] as well as mood instability [13].

Idiopathic musculoskeletal pain has been associated with both stress and sleep interference [14]. Indeed, pain severity is associated with lack of sleep quality and stress is thought to be related to pain severity, thus contributing to poor sleep along with additional health problems [15]. Also, the quality of sleep is often compromised by pressure pain which relates to the comfort and support of the sleep surface [16]. Many individuals continue to sleep in their beds even after the mattress has lost its support and structure integrity. Anecdotally, it is suggested that a mattress 5 to 7 years old may not provide the adequate support or comfort, however; this varies with original quality, use, and inherent anthropometric changes in the user [17]. In one of our previous studies, we found the average age of the participants' beds was 9.7 years, [18] which contributed in part, to back stiffness and pain upon waking. Presently no universal prescription exists for recommending mattress qualities meeting specific sleep needs of the general population [19].

Neurologically, the regulation of sleep, behavior, and emotion is closely related [20], thus physiologically stress may result in poor sleep quality or duration. Gregory and Sadeh [21] suggest that short sleep escalates stress hormone production which hinders sleep. Additionally, significant increased risk of depression and anxiety is associated with sleeping difficulties [22]. Furthermore, self-reported short sleep duration may be an indicator of emotional stress and sleep disturbances [23].

It has been proposed that the relationship between stress and sleep is bidirectional, in that stress can interfere with sleep and that lack of sleep can increase stress levels [24]. Further, Doane [24] concluded that prior day stress is related to shorter sleep duration and that sleep efficiency is associated with greater stress that next day. One study reported that sleep deprived participants reported significantly greater subjective stress, anger, and anxiety in response to a low-stressor condition [21]. Conversely, mental stress, worry, and anxiety contribute to sleep loss and is related to sleep stage fragmentation [25]. Research has demonstrated that stress has a strong association to

impaired sleep [25] and that life stress may be both a predisposing and a precipitating basis of poor sleep [26,27] which can be linked to anxiety, depression, and mood disorders [28-30]. Furthermore, disturbed sleep has been indicted as a factor in both morbidity and mortality [31].

The purpose of this study was to determine subjective, physical, and emotional stress along with sleep disturbances before and after the introduction of new bedding systems in a population sleeping on beds greater than five years old.

## Methods

### Participants

A total of 46 participants (women=23 and men=23) who owned and slept on commercially made spring mattresses older than 5 years volunteered for the study. After reading a written description of the conditions of the study, all participants signed an informed consent document approved by the University Institutional Review Board. The participants were solicited based on a pre-stress screening and bed age survey. Survey responses indicated that participants were moderately active and without diagnosed mental health conditions or using medication for sleep disorders. Additionally, participants were asked to complete a demographic survey containing items such as age, height, weight, and age of their bed (Table 1).

| Variable | Males (n=23) | Females (n=23) | Total (N=46) |
|---|---|---|---|
| | Means, +SD | Means, +SD | Means, +SD |
| Age (yrs) | 48.24, +11.35 | 44.13, +12.29 | 46.11, +11.38 |
| Ht. (cm) | 178.63, +8.64 | 165.24, +5.92 | 171.91, +9.63 |
| Wt. (kg) | 74.63, +12.46 | 56.55, +11.68 | 77.43, +16.87 |
| Bed age | | | 11.27, +4.27 |

**Table 1:** Demographic variable means by gender.

### Procedures

Prior to the onset of the study, participants were asked to complete a 14 item survey concerning sleep habits and stress related to behaviors manifested by anxiety, stress, and sleep. The items of the stress survey were taken from previously developed and validated stress surveys [17,32-39] and were organized to fit a five-point Likert-like scale with 1=never, 2=about once this week, 3=about twice this week, 4=about every other day, and 5=nearly every day.

The directions given the participants were: "Have you had any of the following things happen to you during the past week? If so, simply circle one of the numbers preceding each of those items". Stress related items on the survey included psychological and physiological stress items and sleep related stress items. Among examples of psychological stress markers were anxiety, worrying, nervousness, among examples of physiological stress markers were digestive problems, chest pain, and tight neck muscles, and examples of sleep related stress were difficulty falling asleep, insomnia, waking tired, and disturbing dreams.

Physiological stress items, psychological and physiological stress items, and sleep stress items were randomly distributed throughout the questionnaire but grouped for analysis. A 10 subject test-retest analysis found the survey to be moderately high in reliability (r=0.78).

Following previously published protocol, the pre-test period required participants to sleep in their own beds or older beds and rate their stress each week for a three-week period [Jacobson, Bader] in order to establish a baseline. Participants rated their stress at the end of each week and were advised to avoid rating their stress following an unusually bad day, heavy alcohol consumption, or any extraordinary emotional or physical event that would not be considered the norm.

In addition to the multiple pre- and post-stress surveys, participants were asked simultaneously to subjectively rate efficiency as their total amount of sleep to total time in bed by using a 100 mm visual analogue scale in which a 50 reflects that the participant slept on only half of the time he/she was in bed. All participants were given instructions on how to calculate sleep efficiency based on the suggestion posited by Breus [32].

At the completion of the pre-test, the experimental phase began with the delivery and setup of the new bed. The beds were medium-priced, unlabeled box-spring mattresses with a medium-firm sleep surface. Each mattress contained foam encased bonnell springs, dense fiber pads with foam, and a damask cover. The new beds were the same size as those that the participants' had slept on originally and participants continued to use their own linen, blankets and pillows. After the delivery of the bedding system, participants rated stress symptoms and sleep to bed ratio at the end of each week for four weeks.

### Statistical analysis

A factor analysis was used to cluster the survey items into similar categories. This resulted in the 14 items to be categorized into three types of stress experiences (physical stress symptoms=8 items, psychological stress symptoms=4 items, and sleep stress symptoms=2 items). Among examples of physical stress items were: muscle tension, headache, irritable. Examples of psychological stress items were: worrying, tenseness, keyed-up, and examples of sleep items were: insomnia, difficulty wakening, and disturbing dreams.

To prevent an atypical week of stress from skewing the data the three weekly pre-test stress ratings were aggregated into one pre-test data set. Similarly, the four-week post-test stress ratings were combined to form two post-test data sets; one after the first two weeks and one after weeks 3 and 4 in order to obtain a mid-test and a post-test. Pre- and post-tests scores for each stress category (physical, psychological, and sleep) were analyzed using ANOVAs with repeated measure and Newman-Keuls post-hoc test. An alpha level of $p<0.01$ was considered to reflect significant differences between pre- and post-test means.

## Results

The survey taken by the participants indicated that the average age of their beds was 11.27 years (SD+4.27 years) with a range between 6 and 18 years, well over the recommended usage (Table 1). All analyses were conducted by controlling for bed age, participants' age, and bed cost. A repeated measures ANOVA analysis of pre-, mid-, and post-test physical stress yielded a significant ($p<0.001$) difference among means ($F=43.67$) and the post-hoc tests indicated that significant differences existed between pre- and post-test, between mid- and post-test, but not between pre-and mid-tests (Tables 2 and 3).

| Variable | N | Mean ± SD | -95% CI | +95% CI |
|---|---|---|---|---|
| Physical Pre | 46 | 2.57 ± 1.33 | -2.74 | 2.31 |
| Physical Mid | 46 | 2.40 ± 1.00 | -2.56 | 2.24 |
| Physical Post | 46 | 1.73 ± 0.94 | -1.82 | 1.82 |

**Table 2:** Pre-mid, and post-physical stress means, standard deviations, confidence intervals and probability: F=43.67, p<0.001

| | **Physical Pre** | **Physical Mid** | **Physical Post** |
|---|---|---|---|
| Physical Pre | | 0.23 | <0.001* |
| Physical Mid | 0.23 | | <0.001* |
| Physical Post | <0.001* | <0.001* | |

**Table 3:** Newman-Keuls post hoc test of physical stress (*Significant at p<0.01).

For psychological stress similar results were found in that a significant (p<0.001) difference existed among means (F=11.86) with the post-hoc tests reflecting significant differences between pre- and post-test, between mid- and post-test, but not between pre-and mid-tests (Tables 4 and 5).

| **Variable** | **N** | **Mean ± SD** | **-95% CI** | **+95% CI** |
|---|---|---|---|---|
| Psych Pre | 46 | 1.70± | | 1.85 |
| Psych Mid | 46 | 1.44± | | 1.54 |
| Psych Post | 46 | 1.37± | | 1.48 |

**Table 4:** Pre-mid, and post-psychological stress means, standard deviations, confidence intervals and probability: F=11.85, p<0.001.

| | Psych Pre | Psych Mid | Psych Post |
|---|---|---|---|
| Psych Pre | | <0.001* | <0.001* |
| Psych Mid | <0.001* | | 0.35 |
| Psych Post | <0.001* | 0.35 | |

**Table 5:** Newman-Keuls post hoc test of psychological stress (*Significant at p<0.01).

Similarly, for the sleep/stress category, mean differences were significant (p<0.001) among means (F=14.56) and the post-hoc analysis found significant differences between pre- and post-test, between mid- and post-test, but not between pre-and mid- tests (Tables 6 and 7). A follow-up of the participants resulted in a 97% agreement that the change in beds resulted in greater comfort and sleep quality. Participant's sleep ratio was measured and defined as the amount of time spent in bed compared to the amount of time the participant felt he/she slept. Participant's sleep efficiency improved significantly (p<0.01) between pre- and post-measurements.

| Variable | N | Mean ± SD | -95% CI | +95% CI |
|---|---|---|---|---|
| Physical Pre | 46 | 1.93 ± 1.13 | -2.12 | 1.74 |
| Physical Mid | 46 | 1.84 ± 1.02 | -2 | 1.65 |
| Physical Post | 46 | 1.47 ± 0.78 | -1.61 | 1.34 |

**Table 6:** Pre-, mid, and post-sleep stress means, standard deviations, confidence intervals and probability: F=1.58, p<0.001.

| | **Sleep Pre** | **Sleep Mid** | **Sleep Post** |
|---|---|---|---|
| Sleep Pre | | 0.22 | <0.001* |
| Sleep Mid | 0.22 | | <0.001* |
| Sleep Post | <0.001* | <0.001* | |

**Table 7:** Newman-Keuls post hoc test of psychological stress (*Significant at p<0.01).

## Discussion

Among common psychological signs of stress are depression, worry, moodiness, and irritability, common physical signs include aches, digestive disorders, muscle tension, and headache, and signs of sleep interference include difficulty falling asleep and insomnia. These factors were included in the 14 item stress survey in which the participants subjectively rated their stress from never to nearly every day at the end of each week, before and after changing from their old beds to new beds. Of the three stress categories, the pre-physical stress indicators were more prominent with sleep disturbance showing a 32% reduction with the introduction of a new sleep surface. The sleep stress association and the psychological stress improved 22.2% and 22.0% respectively from pre- to post-evaluations.

Several previously conducted studies have found that that stress correlates with sleep [30,34]. Conversely, the lack of sleep whether from work-related duties or other demands can result in stress-like symptoms both physical and psychological in nature. Others studies [29,33] have indicated that reduced sleep is related to anxiety, irritability, anger, and depression.

The current study demonstrated that the participants' beds averaged over a decade in use (Mean=11.27 years). These results of better sleep efficiency resemble those of Enck and associates [19] who determined that new mattresses provided statistically better sleep quality than "old" mattresses (8-yr). It is reasonable to assume that a bed used over ten years may not fulfill the users sleep needs adequately.

The participants' beds may have been compromised due to age and use thereby having lost both structure integrity and support qualities. Such beds may not afford the comfort of a sound sleeping surface and may result in physical discomfort which can interfere with sleep [36,37] thus adding to daytime stress. Additionally, many experience body changes over 10 years due to work-related conditions, physical changes, and aging which may warrant looking into a new sleep surface rather than to depend on pharmaceuticals to achieve better sleep.

The results of the present study reflect a significant improvement in the three stress-related categories after the removal of the old beds and delivery of the new beds. Furthermore, participants indicated they slept more while in the new bed than when sleeping in their old bed.

A limitation to this study is that the subjects acted as their own control without a true control group. As has been noted previously [36] a control group is not practical in a study such as this since a control or sham bed would constitute the introduction of yet another new sleep surface. The question becomes, what should be the makeup of a sham bed? The current research was based on previous protocols in which no sham beds were used [19,38,39], but rather compared firmness of separate beds or adjustable beds. One study [40] did compare new beds to beds 8-yrs old and found significantly greater sleep quality in the newer beds.

Similar to the current study, a placebo effect may have resulted in the initial positive responses to stress by the mere fact that a "new" mattress was available. Others have addressed the possibility of a placebo effect [37]. While a placebo effect may have been present in the initial stages of the study. We suggest that if a placebo effect had compromised the post-observations it must have been present at the first data collection point (mid-test), however, the significant improvement in each stress category continued to the end of the study. Placebo sustainability varies by the variables observed, but eventually the placebo effect begins to diminish. It is likely that once the "new" wears off, the efficacy of the intervention diminishes. Additionally, the sample size may be considered small, however; similar studies [39,40] involved fewer participants.

Mimicking previous studies, the current study employed a medium-firm [37,41,42] innerspring mattress as the experimental bedding system. However, no universal standards presently define the firmness of mattresses. Such definitions are the construct of the mattress companies. Continued research in the area should focus on sleeping surface comparisons and assessment of the longevity and sustainability of the support and comfort of the bedding system.

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