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Original articles

Changes in back pain, sleep quality, and perceived stress after introduction of new bedding systems☆

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Abstract

Objective: This study compared sleep quality and stress-related symptoms between older beds (≥5 years) and new bedding systems.

Methods: A convenience sample of healthy subjects (women = 30; men = 29) with minor musculoskeletal sleep-related pain and compromised sleep, but with no clinical history of disturbed sleep, participated in the study. Subjects recorded back discomfort and sleep quality upon waking for 28 consecutive days in their own beds (baseline) and for 28 consecutive days (post) on a new bedding system using visual analog scales. Following baseline measures, participant's beds were replaced by new, medium-firm beds, and they again rated their sleep quality and back discomfort. Stress was assessed by a modified stress questionnaire.

Results: Repeated-measures analysis of variance was used to treat sleep quality and efficiency and factored responses of the stress items. Results indicated that the subjects' personal bedding systems average 9.5 years old and were moderately priced. Significant ($P < .01$) improvements were found between pre- and posttest mean values in sleep quality and efficiency. Continued improvement was noted for each of the 4-week data gathering period. Stress measures yielded similar positive changes between pre- and posttest mean values.

Conclusion: Based on these data, it was concluded that, in this population, new bedding systems increased sleep quality and reduced back discomfort, factors that may be related to abatement of stress-related symptoms.

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Introduction

Seventy-five percent of Americans report that they have sleep problems a few nights per week or more.[1] A projected 70 million people are currently affected by sleep problems, and by the middle of the 21st century, that figure is expected to reach 100 million.[2] It has been estimated that the average individual gets about 6.8 hours of sleep per night,[1] which can equate to symptoms of sleep deprivation and has the potential to relate to a negative quality of life.[3] Sleep is restorative both physiologically and psychologically and aids in healing and repair,[4] whereas sleep deficiency is related to loss of work production, increased sick days, greater absenteeism, loss of productivity, and higher injury rates.[5-9]

A popular medical dictionary defines insomnia as the inability to sleep or to remain asleep throughout the night.[10] Others[11] have defined insomnia, for the benefit of their study, as problems sleeping for 3 nights or more per week during the past 3 months, in addition to problems with daytime functioning. Feige et al[12] defined insomnia as characterized by low subjective sleep quality. Sleep quality, although poorly defined, is a key feature in insomnia.[13] Poor sleep quality is associated with a continuous activation of the 2 major components of the stress system: the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system.[14] Furthermore, stress is related to impaired and shortened sleep, sleep fragmentation, and possibly a reduction in sleep stages III and IV.[15] Those who demonstrate higher stress levels have been shown to have significantly lower sleep efficiency.[6] One survey estimated that 65% of Americans are losing sleep because of stress.[16]

Although stress can cause sleep loss, the reverse is also possible. For instance, poor sleep quality can contribute to an increase in perceived stress. Lack of sleep can intensify the degree of stress,[17] and shortened or disturbed sleep causes increases in levels of traditional stress markers[6] and may exacerbate the effects of stress.[18-20] Both mental and physical processes decline with inadequate sleep. Poor sleep quality is associated with anxiety, depression, and mood disorders.[14,17,21] Conversely, adequate sleep improves attitudes, moods, and promotes feelings of self-esteem and competence. Indeed, it has been concluded that lack of sleep is a significant stressor, and chronic sleep problems can themselves become a source of stress.[22] In addition, sufficient sleep improves mood, promote feelings of competence and self-worth, and supports optimal mental and emotional function.[17]

The comfort and support of the sleep surface are related to problems of sleep quality and efficiency.[23] Certain sleep surfaces have resulted in complaints of low back discomfort, pain, or stiffness and shoulder pain.[24,25] One study found that subjects developed back pain after sleeping on foam mattresses.[26] Another study found no significant differences between foam and innerspring mattresses in sleep stages, number of wakes, or total sleep time.[27] In a comparison of beds described as "hard," "softer," water, and water/foam, subjects with current back pain reported reduced pain after sleeping on "hard" beds.[28] Jacobson et al,[29] in 2 separate studies, found that medium-firm mattresses reduced clinically diagnosed back pain, shoulder pain, spine stiffness, and positively affected sleep quality and that even subjects with minor sleep disturbances benefited significantly in sleep quality and efficiency with medium-firm bedding systems.[30] Furthermore, Hadler and Evans[31] concluded that medium-firm mattresses served to reduce low back pain more so than firm mattresses.

Presently, no formula exists for recommending bedding systems to meet specific sleep needs or for reducing sleep disturbances.[32] Health care professionals have little information to support recommending sleep surfaces. However, Jacobson et al[29] suggested that body weight may be one determining factor for choosing a bed. Despite the lack of guidelines and cautions that physicians should avoid recommending firm mattresses, 75% of orthopedic surgeons' recommended firm or hard mattresses for the relief of back pain.[33] The purpose of this study was to compare related stress variables to sleep quality and efficiency before and after the introduction of new, medium-firm bedding systems.

Methods

Subjects

The subjects consisted of a sample of healthy women (n = 30) and men (n = 29) who owned and slept on commercially made spring mattresses at least 5 years old. Before data collection, subjects read and signed an informed consent document approved by the university institutional review board. Subjects were limited to working adults who owned and slept in their own beds and who agreed to honestly and systematically complete daily sleep ratings. The subjects were chosen from a pool of volunteers with similar characteristic. Body mass index was limited to those

within the range of 18.5 to 29.9. The subjects were moderately active and without diagnosed physical or psychologic pathology or on medication for stress, anxiety, pain, or sleep disorders. Based on a preliminary screening questionnaire, participants noted occasional and typical sleep disturbance caused by mild physical pain or stress and were further screened by using the Pittsburg Quality Sleep Index. Such incidences of pain and stress were considered "normal" in contrast to clinically diagnosed and treated (manipulatively or pharmaceutically) conditions. During the study, subjects were asked to report any new physical, psychologic, or pharmaceutical occurrence so that reevaluation of the subject could be taken into consideration. Subjects' physical data are illustrated in Table 1. 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.

Procedures

Before the onset of the study, subjects were asked to complete a questionnaire concerning sleep habits and a stress questionnaire containing 32 items related to behaviors manifested by anxiety and stress. Visual analog scales (VASs) were used to assess the participants' perception of sleep quality and low back pain and were to be filled in each morning upon rising. The VASs consisted of 10-cm lines used to assess sleep quality and contained "excellent" and "poor" and the VASs for back pain contained "none" and "extreme pain" on the left and right extremes of the line. Participants were asked to place a mark on the line indicating their previous night's sleep quality. Visual analog scales have been found to be reliable and highly correlated with Likert-like scales.[34] Such scales provide an accurate measure of subjective variables and are commonly used in similar research.[29,30,35-37]

Stress was assessed via a questionnaire containing 32 items related to symptoms and behaviors manifested by anxiety and stress. For analysis, the 32 items were clustered by using an oblique factorial analysis. The stress questionnaire items were 5-point Likert scale items related to the number of occurrences of stress behavior and symptoms over the previous 2 weeks. Responses ranged from "never" to "nearly every day." The items of the questionnaire were captured from previously developed psychologic[17] and physiologic[38,39] surveys that provide information on how much stress an individual exhibits or perceives. The survey lists behavioral manifestations such as trembling/ticks, dry mouth, cold hands, stomach ache, grinding teeth, tightness in the chest, and so on, and psychologic/perceptual stress such as tension, forgetful, irritable, mind going blank, nervousness, keyed up, worrying, and so on.

As has been suggested by Bader and Engdal,[40] to reduce external, contraindicating factors and to provide the most natural sleep environment, the subjects slept in their own bedrooms, and with their personal linen and pillows. Subjects also controlled their own preferred thermal environment. Following previously published protocol, the pretest period required subjects to sleep in their own beds and to rate their sleep each morning for a specified period[29,40] to establish a baseline. Similarly to other studies, the baseline rating extended for 28 consecutive days.[29,37] Subjects rated the categories each morning after sleeping in their own bed and were advised to avoid rating their sleep after heavy alcohol consumption, trauma, or any extraordinary emotional or physical event that could have detrimental effects on sleep. After the 28-day baseline period, all subjects completed the 32-item stress questionnaire.

At the completion of the pretest, the experimental phase began with the delivery and setup of the new bedding systems. The beds were unlabeled and exclusively manufactured for this study. Beds contained a medium-firm sleep surface, foam-encased bonnell spring unit, densified fiber pad, super-soft foam, damask cover, semiflex foundation, and slick fiber. Experimental beds were the same size as those that the subjects' had slept on originally. Subjects continued to use their own linen, blankets, and pillows. After the delivery of the bedding system, subjects began rating sleep quality and efficiency for the next 28 consecutive days, and at the end of the 28-day period,

Table 1 Demographic variable mean values by sex

Variable	Males (n = 29)	Females (n = 30)	Total (N = 59)
Age (y)	Mean = 46.89 SD = 11.3	Mean = 43.43 SD = 10.8	Mean = 45.14 SD = 10.9
Height (cm)	Mean = 179.04 SD = 7.62	Mean = 165.0 SD = 5.59	Mean = 171.91 SD = 9.63
Weight (kg)	Mean = 89.73 SD = 11.9	Mean = 65.55 SD = 1.52	Mean = 77.43 SD = 16.87
BMI	Mean = 27.79 SD = 3.74	Mean = 24.55 SD = 4.16	Mean = 25.94 SD = 4.27

BMI, Body mass index.

subjects again completed another 32-item stress questionnaire. Subjects were told that the bedding system was theirs to keep at the end of the study if so desired.

Statistical analysis

The 28-day mean values for the pretests were established for sleep quality and efficiency as the baseline for each dependent variable and subsequently compared to the 28-day mean values for the posttest. Posttest mean values for sleep quality and back pain were separated by weekly aggregated mean values for analysis. All dependent variables were analyzed using analyses of variance (ANOVAs) with repeated measures. Neman-Keuls post hoc tests were used to treat significant group differences. An α level of $P < .05$ was considered significant.

As has been previously done with stress surveys,[6] an oblique factor analysis was used to compress the related variables of the 32 stress questionnaire items into 2 single items of maximum likelihood representing the construct of stress-related factors. Determining to include factors was dependent on eigenvalues and percent variance of each factor. The interpretations of the 2 factors that were included for analysis were as follows: factor 1, perceived stress symptoms (ie, anxiety, irritable, etc); factor 2, physiologic stress symptoms (ie, sweaty palms, dry mouth, etc). Data from the aggregated stress items were analyzed by ANOVAs with repeated measures. Neman-Keuls post hoc tests were used to treat significant group differences. An α level of $P < .05$ was considered significant.

Results

Analysis of baseline and experimental mean values yielded significant improvements in sleep quality

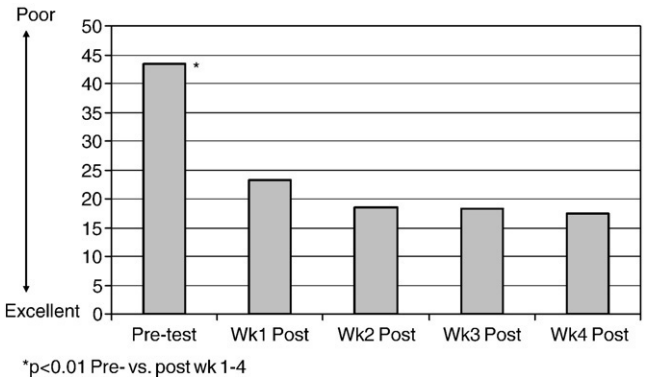

Fig 1. Pre and post mean values for sleep.

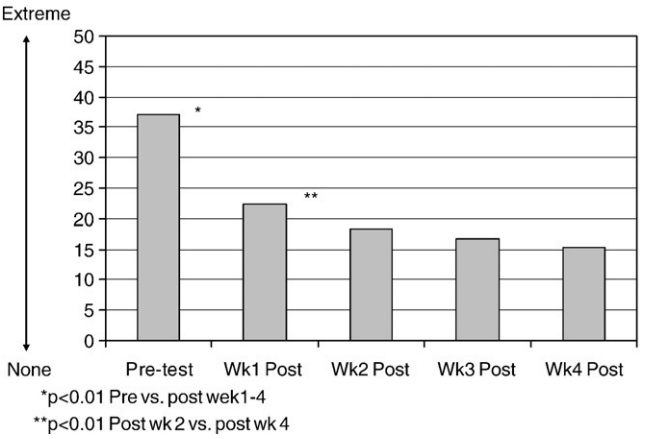

Fig 2. Pre and post mean values for low back pain.

($P < .001$). Post hoc analysis indicated that sleep quality was significantly better ($P < .0001$) for each of the 4-week posttest mean values when compared to the pretest mean and continued to improve to the extent that sleep quality was significantly better ($P < .05$) at posttest week 4 than posttest week 1 (Fig 1). Analysis of baseline and the 4-week posttest mean values also resulted in significant differences in back pain ($F = 11.24$; $P < .01$), and post hoc analysis of the 4-week mean values resulted in significant differences between week 1 and weeks 2 to 4 (Fig 2). Posttest weekly mean values for sleep quality and lower back pain improved consistently over each of the 4.

The factor analysis technique identified a 9-item factor representative of the construct of perceived stress symptoms: worrying, cannot turn off thoughts, irritable, keyed up, headache, disturbing dream, nervousness, stomach ache/upset, and insomnia, and a 5-item factor representative of stress behavior: tremor/trembling, twitch/tic, bounce, jerk foot, and dry mouth. Reliability of the resulting scales was high for both factors (Cronbach $\alpha = .81$ and .80, respectively). Results of repeated-measures ANOVAs yielded significant differences between pre- and posttest mean values for factor 1 ($P < .001$) and factor 2 ($P < .001$).

Discussion

In the present study, medium-firm bedding systems reduced back pain by approximately 48% (37.1 [pre mean] − 19.3 [post mean week 1-4] = 17.8/37.1 = .48) and improved sleep quality by 55% (43.5 [pre mean] − 21.0 [post mean week 1-4] = 22.5/43.5 = .52). Indeed, greater proportional improvement would have been

possible had only the fourth (last) week mean rather than the mean for the total 4-week period been used for sleep quality (17.4 vs 21.0, respectively) and low back discomfort (15.1 vs 19.3, respectively) in the calculation because improvement continued each week over the 4-week posttest measures. Furthermore, the present study found that the significant increase in sleep quality and pain reduction was paralleled by a significant decrease in stress. Some studies have concluded that the sleep surface can contribute to discomfort[24,25] and that sleeping on certain sleep surfaces may be more beneficial than others. Yet, others[27] found no significant differences in sleep stages or sleep efficiency when comparing sleep surfaces. For instance, Bader and Engdal[40] found no difference in sleep quality when comparing subject's personal beds and 2 commercially available beds, one labeled "soft" the other "hard." Conflicting conclusions likely stemmed from contrasting research protocols such as the duration in which the participants slept on the beds, method of assessment, and environmental factors (ie, laboratory vs home) in addition to the sleep surfaces.

Previous studies in agreement with the present data also concluded that medium-firm mattresses positively affected sleep quality[29] and that medium-firm mattresses can be recommended to ease nonspecific low back pain.[41] Several studies have concluded that stress is highly related to poor sleep quality[6,15,18-20,42-45] and that stress has been associated with insomnia and insufficient sleep.[14,42,46,47] Less defined is the reverse association between sleep quality and stress. The results of the current investigation agree with those who have concluded that sleep quality is associated to stress, suggesting that improved sleep quality may reduce stress and stress-related behavior. For instance, Fuligni[18] found that obtaining less sleep at night is related to greater anxiety and depressive feelings. Meltzer and Mindell[48] also concluded that sleep quality was a significant predictor of mood and stress. Furthermore, others have reported an association between poor sleep quality and insomnia, depression, anxiety, irritability, and anger.[21,49,50] One study[43] reported a very high ($P < .0001$) correlation between poor sleep quality and depression and anxiety. Fuligni[18] found that less sleep was related to more negative and less positive moods and that more sleep yielded lower depressed feelings.

The results of the present study indicate that participants' sleep quality significantly improved with the replacement of the old (mean, 9.5 years) sleeping surface. Furthermore, the improvement in sleep quality was realized within the first week of the presentation of the new bedding system and not only sustained but also improved for the remainder of the posttesting period by 24.2%% from week 1 to week 4. Similarly, stress symptoms and behavior as measured by the factored items from the questionnaire were significantly reduced after 4 weeks of sleeping on the new bedding. For factors 1 and 2, stress abated by 19.5% and 21.5% from pre- to posttest, respectively. Fig 3 illustrates the relationship between improved sleep quality and efficiency and stress.

Stress can be chronic or acute, and unabated stress has been associated with mental health disorders.[51] No participant in the current study had chronic stress or had been treated for related emotional disorders; however, it is remotely possible that some participants were faced with acute stress at the time of completing the pretest stress survey before the introduction of the new bedding system and it is further possible that this stress had abated naturally at the end of the 28-day recording session after sleeping on the new bedding system. However, it is doubtful that most of the participants experienced such an event at precisely the same time and to the degree that stress changed so drastically from the pre- to posttest. Furthermore, the increase in perceived sleep quality follows the same trend as the abatement of stress. Such results serve as further indication that sleep and stress are interrelated. It may be likely that a reduction in physical discomfort may have accompanied greater sleep quality and efficiency,[29,52] thus reducing stress levels.

As is common with most sleep surface research, no control group was used for comparisons,[28,29,32,37,40,41] but rather the group served as its own control. It is axiomatic that a control group strengthens the research design by reducing the threat for a Rosenthal effect. Jacobson et al[29] suggested that a "control" or placebo

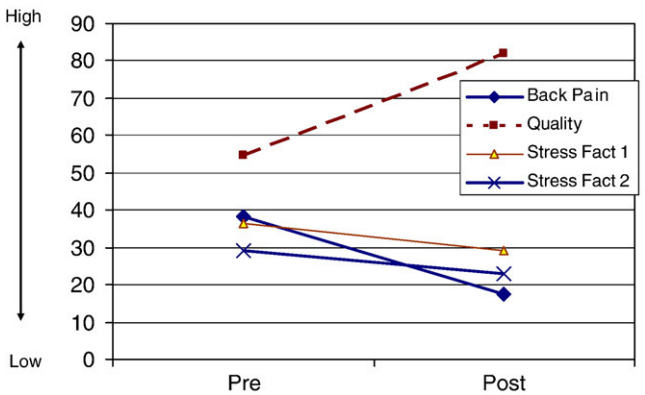

Fig 3. Relationship between sleep quality, back pain, and stress.

bedding system is inconceivable in this type of study because there is no definition of a placebo bed, and if a sham bed could be put in place, the "control" bedding system would serve as an additional experimental bedding system and not a standard of measurement.[30] Several other similar studies[29,37,40] followed the protocol used in the current study by having the participants use their personal bedding systems as the baseline for data collection.

Another limitation of study was that the mean age of the participants' bed was 9.5 years. It may be reasonable to assume that any bed with a certain amount of use will not provide the same benefit as a newer model. Yet, analysis comparing categories of bed age and sleep quality did not yield any significant differences in pretest sleep quality.

It may be argued that subjects favored the experimental bedding system simply because it was new and/or that the positive changes could be attributed to a Hawthorne or Rosenthal effect. Although there are several examples/definitions of the Hawthorne effect in literature, a common combination of definitions suggests that people will respond to any novel change, not because of any specific condition being tested but because of the attention they receive. Without a control group, it is impossible to compare true treatment with sham treatment. However, participants were not obtrusively observed nor continually monitored but rated their sleep for 2 full months privately and with no change in attention during the experimental phase. Yet, we did not rule out the possibility that given a 'free' bed, participants wished to please the researchers by overstating their benefits. With respect to the Rosenthal effect, it may be argued that subjects favored the experimental bedding system simply because it was new and that they could have concluded by the questionnaires and the VAS that the desired outcome should be greater sleep quality and a reduction in stress. However, subjects were not overtly given any information as to what outcome was expected. One may anticipate that the initial installation of the new bedding systems would have accounted for an immediate peak in perceived improvement, followed by a return toward pretest ratings. Although the first week of the posttest yielded a significant improvement ($P < .0001$) in sleep quality over the pretest period, improvement for posttest weeks 2, 3, and 4 continued to increase rather than diminishing. Furthermore, the follow-up questionnaire supported sustained improvements and satisfaction when compared to the responses of the initial questionnaire.

Bader and Engdal[40] suggested that new bedding systems may improve sleep initially due to a "pseudo placebo effect." A placebo effect may have been reflective of the first week or two with the new bedding system but should have begun to weaken over time. Again, in the present study, the benefits in sleep quality and efficiency were greater for each of posttest observations, suggesting a continued benefit. Bader and Engdal[40] suggested that it may take more than 5 nights to adapt to the new sleep surface. Daily data for the present study suggested that improvement was realized more immediately.

Caution should be had in assuming generalizability of these data. For instance, stress stems from many sources and the abatement of stress may be difficult to achieve. Certainly, sleep is associated with stress; however, it would be an oversimplification to suggest that a new bedding system is a panacea for stress management.

A wide selection of sleep surfaces with varying levels of firmness and support are available at a broad range of prices.[30] It has been estimated that more than 80% of the American public sleep on innerspring mattresses.[53] As previously done by others the current study used a medium-firm[29,31,41] innerspring mattress as the experimental bedding system and found immediate and significant improvements in sleep quality, sleep efficiency, and stress among participants. No benchmark standards presently exist for recommending bedding systems, whether for the purpose of alleviating pain-related sleep disturbance, stress, or for the purpose of enhancing sleep quality. Recommendations of medium-firm mattresses,[29-31] hard beds,[28] or suggesting that no difference exist between sleep surfaces[27] add to the confusion. Indeed, the ideal mattress is yet to be determined and likely depends on many variables illustrating the need for additional research. It may be overly optimistic to conclude that one type of mattress fits all individuals because of the range of varied anthropometric characteristics of the human body.

In this instance, the participants' beds averaged more than 9 years old, suggesting that they had spent an average 3 years in their beds. It is highly plausible that although mattresses and bedding surfaces are accompanied by extended warranties, the life of the support, structure, and comfort of the mattress as it relates to sleep quality may be considerably less than commonly assumed. Continued research in the area should focus on sleeping surface comparisons and assessment longevity and sustainability of the support and comfort of the bedding system.

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