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Effects of an adapted mattress in musculoskeletal pain and sleep quality in institutionalized elders

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ABSTRACT

We aimed to evaluate the impact in sleep quality and musculoskeletal pain of a Medium-Firm Mattress (MFM), and their relationship with objective sleep parameters in a group of institutionalized elders. The sample size included forty older adults with musculoskeletal pain. We did a clinical assessment at baseline and weekly trough the study period of four weeks. We employed the Pittsburgh Sleep Quality Index (PSQI) and Pain Visual Analog Scale (P-VAS). Additionally a sub-group of good sleepers, selected from PSQI baseline evaluation, were studied with actigraphy and randomized to MFM or High Firm Mattress (HFM), in two consecutive nights.

We found a significant reduction of cervical, dorsal and lumbar pain. PSQI results did not change. The actigraphy evaluation found a significant shorter sleep onset latency with MFM, and a slightly better, but not statistically significant, sleep efficiency. The medium firmness mattress improved musculoskeletal pain and modified the sleep latency.

1. Introduction

Quality of sleep is associated with age-related changes, medical or psychiatric diseases and primary sleep disorders. Aging, itself, modifies the sleep architecture, with disruption of the sleep-wake cycle and increasing arousals and awakenings [1]. The National Sleep Foundation, in the Sleep in America Survey, reported that about 52% of the older adults with major comorbidity reported one or more sleep problems, compared with 36% of the participants reporting no comorbidity [2]. Likewise, several studies found that disturbed sleep is rare in healthy older adults [3].

The sleeping thermal environments, including the mattress and bed equipment (sheets, blankets and pillows), play a role in quality of sleep [4]. One survey estimated that 7% of sleep problems were related to an uncomfortable mattress [5] contributing to poor quality of sleep or physical discomfort. Moreover, several studies indicate that a mattress with ergonomic standards could improve the quality of sleep

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[6,7]. Some studies evaluate the association between sleep surface, sleep quality and pain (back and shoulder) [8,9]. Bader et al. [10] concluded that mattress differences did not significantly affect sleep quality, whereas others consider that those with different firmness or construction can affect quality of sleep [11].

Our aim was to evaluate the impact of a Medium-Firm Mattress (MFM) on sleep quality and musculoskeletal pain in institutionalized elders, and to evaluate in a subgroup of good sleepers the effect in sleep parameters through actigraphy.

2. Materials and methods

We conducted a quasi-experimental study.

2.1. Participants

All the participants were institutionalized older adults (>60 year old), who slept on foam mattresses on an adjustable bed in a public nursing home. In order to find the sample size, we used the formula for studies of contrast hypothesis. We included 40 subjects with musculoskeletal pain who were evaluated by a geriatrician. Evaluation included BMI, polypharmacy, nutritional status and nicturia. Exclusion criteria were: bedridden subjects, moderate to severe dementia, acute illness and subjects who had recent surgery. Additionally, all patients with normal PSQI and without psychotropic medication at baseline were studied for two nights with actigraphy.

2.2. Ethical approval and informed consent

The study protocol was approved by the Institutional Review Board of the Universidad Peruana Cayetano Heredia. Informed consent was obtained prior to initiation of the study.

2.3. Questionnaires and devices

The Pittsburgh Sleep Quality Index (PSQI) is an 18-item self-report questionnaire. The items produce seven component scores which range from 0 (no difficulty) to 3 (severe difficulty): sleep duration, sleep disturbance, sleep latency, daytime dysfunction, habitual sleep efficiency, sleep quality, and use of sleep medications. The sum of these component scores yields a measure of global sleep quality which ranges from 0 to 21. A global PSQI score greater than 5 has a diagnostic sensitivity of 89.6% and specificity of 86.5% in distinguishing good and poor sleepers [12]. We used the Pittsburg Sleep Quality Index validated in Colombia (ICSP) [13].

The Pain Visual Analog Scale (P-VAS) measurement was introduced by Huskisson [14]. It is a continuous scale, 10 cm in length, anchored by 2 verbal descriptors. The P-VAS for musculoskeletal pain contained “no pain” on the far left and “extreme pain” on the far right side of the line.

The Actiwatch 2 (Phillips-Respironics) is a portable device with the size of a large wrist watch, and it consists of a solid state “piezoelectric” accelerometer with a range of 0.5–2 G, bandwidth 0.35–7.5 Hz, Sensitivity of 0.025 G and a sampling rate of 32 Hz. This instrument is validated for different sleep disorders [15], the American Academy of Sleep Medicine (AASM) has concluded that an actigraph can provide objective measures of sleep patterns [16]. In older adults (including older nursing home residents), in whom traditional sleep monitoring can be difficult, actigraphy is indicated for characterizing sleep and circadian patterns and to document treatment responses due its high sensitivity [17].

The Actiwatch 2 database was analyzed using Encore Pro 2 version 2.2 (Patient Management System) software [18,19]. The database include Bed Time (BT), Get up Time (GT), Sleep Onset Latency (SOL), Wakefulness after Initial Sleep Onset (WASO), Number of Awakenings (NA), Total Sleep Time (TST), Total Time Spent in Bed (TIB), Sleep Efficiency (SE).

2.4. Procedures

All the selected participants that fulfilled the inclusion and exclusion criteria completed the P-VAS and PSQI. The regular mattresses of the 40 participants were changed to Medium Firm Mattress (MFM). Subjects slept in their own beds with their personal linen and pillows without thermal additional modifications. A follow up was done using P-VAS every week, during 4 weeks. Participants completed the PSQI at the end of the 4 weeks evaluation.

In the actigraphy evaluation, the subjects were randomized between MFM and HFM, the transition between MFM and HFM was at random sequences for two consecutive nights.

The P-VAS and PSQI were applied by a blinded evaluator. For the Actigraphy evaluation, participants and the evaluator were blinded about which mattress was used each night. An independent researcher analyzed the outcome and the statistical correlations.

2.5. Mattress

The hardness of each mattress was measured in Newtown with a calibrated durometer. Mattress features are described in Table 1. Additionally, hardness was rated through a VAS in a healthy group of volunteers. The scale ranged from 1 (hard) to 10 (soft). The MFM was rated as 3–6 in 80% of volunteers.

2.6. Statistic analysis

Data were analyzed using SPSS for Windows version 13.0 (Chicago, IL, USA). Demographic data are presented using descriptive statistics, for categorical variables we used frequencies and percentages and for numeric variables, mean and standard deviation. The analysis of associations of variables was performed using chi-square and ANOVA. Age, BMI, Nicturia, Psycotrophic medication, polypharmacy, variation in P-VA for cervical, dorsal and lumbar pain were used for Spearman correlation analysis. In the actigraphy evaluation, quantitative variables were analyzed using nonparametric tests and qualitative variables were dichotomized and evaluated with Fisher's exact test. Statistical significance was set at $p<0.05$.

3. Results

The population selected for the study is described in Fig. 1.

Table 1 – Mattress characteristics.

Features	MFM	HFM
Thickness	0.151 m	0.155 m
Size	Large: 2 m; width 0.90 m	Large: 1.96 m Width 0.91 m
Foam	Foam 1: viscoelastic polyurethane Foam 2: high-resilience polyurethane	Foam: polyurethane
Density	Foam 1: 40 kg /m^3 Foam 2: 38 kg/m^3	Foam: 20.2 kg/m^3
Hardness	Foam 1: 28 N Foam 2: 55 N	Foam: 75–80 N
Cover	Fabric white color Lateral zippers non eyelets	Vinyl light gray Anterior zipper with eyelets
Time of use	New	New

MFM = Medium Firm Mattress; HFM = High Firm Mattress

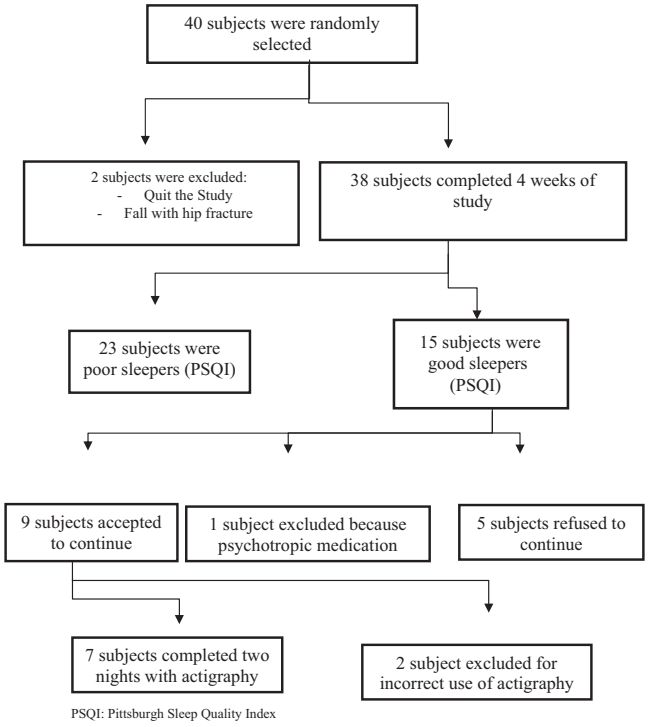

Fig. 1 – Population Study. PSQI: Pittsburgh Sleep Quality Index.

The mean age of the study population was 78.4 ± 8.7 years old, the mean weight was 69.7 ± 13.5 kg and the Body Mass Index (BMI) was 25.7 ± 3.9 kg/m^2. The general characteristics are shown in Table 2.

The P-VAS showed a significant reduction of cervical, dorsal and lumbar pain since the first week of evaluation and was steeply reduced through the 4 weeks of evaluation (Table 3; Fig. 2). However, the percentage of poor sleepers (PSQI > 5) did not reach significant reduction after 4 weeks of MFM use, 23 (60.5%) vs 19 (50%), $p = 0.245$.

Table 2 – General characteristics of sample study.

	Subjects N = 38
Gender	
Female, N (%)	21(55.3)
Male, N (%)	17(44.7)
Dorsal, lumbar or cervical pain, N (%)	38(100)
≥ 3 comorbidities, N (%)	2(5.3)
Psychotropic medication, N (%)	14(36.8)
Polypharmacy	
≥ 3 medications, N (%)	12 (31.6)
Nicturia, N (%)	27(71.1)
Nutritional status	
Obese, N (%)	7(18.4)
Overweight, N (%)	13(34.2)
Eutrophic, N (%)	12(31.6)
Undernourished, N (%)	1(2.6)

Table 3 – Musculoskeletal pain.

Musculoskeletal pain	Week 0	Week 4	p
Lumbar pain			
P-VAS(mean ± SD)	5.47 ± 1.7	2.4 ± 1.8	< 0.001
Cervical pain			
P-VAS(mean ± SD)	4.5 ± 2.4	1.9 ± 1.7	< 0.001
Dorsal pain			
P-VAS(mean ± SD)	2.1 ± 3.1	0.7 ± 1.3	< 0.01

P-VAS: Pain Visual Analogue Scale.

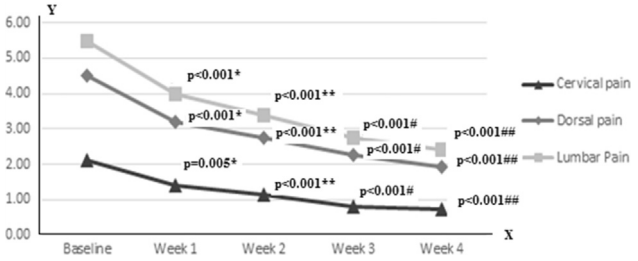

Fig. 2 – Variation of cervical, dorsal and lumbar pain. *Week 1 vs Baseline P-VAS **Week 2 vs Baseline P-VAS # Week 3 vs Baseline P-VAS ## Week 4 vs Baseline P-VAS.

Correlation analysis showed no association for polypharmacy, age, BMI, nicturia, psychotropic medication with variation of cervical, dorsal and lumbar pain (Table 4).

Among the subgroup of patients with normal PSQI at baseline, studied with actigraphy, a significant shorter SOL with MFM, and a slightly but not statistically significant lower SE with HFM were observed (Table 5).

The variation of SOL for the switch in a single night between HFM and MFM did not show a significant correlation with the improvement of lumbar pain ($r = 0.412$; <rho> = 0.359), dorsal pain ($r = 0.491$; <rho> = 0.263) and cervical pain ($r = -0.577$; <rho> = 0.067) at the week 4.

Table 4 – Correlation analysis age, BMI, nicturia, polypharmacy, psychotropic medication and musculoskeletal pain variation.

	V-LP	V-DP	V-CP
Age	−0.126	0.046	−0.058
BMI	−0.074	−0.170	0.112
Nicturia	−0.248	−0.183	−0.119
Polypharmacy	−0.060	−0.006	0.228
Psychotropic medication	−0.162	0.048	−0.141

No significant correlation was found in any variables. V-LP=Variation of Lumbar Pain;V-DP=Variation of Dorsal Pain; V-CP=Variation of Cervical Pain.

Table 5 – Actigraphy parameters between MFM vs. HFM.

Actigraphy parameters	MFM Mean±SD	HFM Mean±SD	*p*
BT	9:24 pm (±2 h 19 min)	8:35 pm (±39.6 min)	0.949
GT	5:49 am (±55 min)	5: 45 am (±1 h 1 min)	0.992
SE (%)	81.62±6.91	73.33±11.92	0.096
TIB	8 h 35 min (±2 h 3 min)	9 h 7 min (±1 h 1 min)	0.084
TST	6 h 52 min (±1 h 59 min)	7 h 11 min (±2 h 25 min)	0.939
SOL	21 min (±17 min)	67 min(±67 min)	<0.001
NA(n)	34.57±12.2	65.21±74.05	0.655
WASO	44 min (±14 min)	57 min(±35 min)	0.565

BT=Bed Time, GT=Get up Time, SE=sleep efficiency, TIB=Total Time spent in Bed, TST=Total Sleep Time, SOL=Sleep Onset Latency, NA=Number of Awakings, WASO=Wakefulness after Initial Sleep Onset, MFM=Medium-Firm Mattress; HFM=High Firm Mattress.

4. Discussion

We found a significant reduction in musculoskeletal pain in a group of senior institutionalized adults with the use of MFM. This result was independent of age, BMI, nicturia, polypharmacy and the use of psychotropic medication. Although, the only variable that improved in the single night switch from HFM to MFM was SOL, it did not correlate with the observed changes in pain.

Limitations of our study were the absence of a control group, the possible bias induced by a new, and provided at no cost, mattress, that could generate a positive response. Other limitation includes, the Hawthorne effect. This phenomenon also referred as the observer effect, is a type of reactivity in which individuals improve an aspect of their behavior in response to their awareness of being observed [8]. In the same way, the brief evaluation of actigraphy, in the single night switch, for each mattress, could limit further adaptation and the possibility to detect changes that could be observed with a more prolonged use. Other limitations are the selection bias and the short number of participants. In order to reduce these biases we conducted an evaluator blinded study, and we also limited the information about the expected outcome of the study to the participants. The sleeping conditions, which include the support of the mattress, pillows, sheets, blankets and sleep environment, were similar in all the participants and the same every night, which is a strength of our study. In future studies it would be important to determine the impact on sleep quality of each component of the bedding system. These components and the season of the year might influence sleep cycle [20], however we ruled out this effect because of steady weather conditions during the four weeks of the study.

The influence of the hardness of a mattress in sleep quality and low back pain is subject of controversy, Bader et al. [10] found no difference in subjective sleep quality between two mattresses, commercially sold as smooth and hard. In the same way, in the present study there was no change in the sleep quality, measured by PSQI. However, a significant reduction in low back pain with a MFM was observed. Moreover, several studies have concluded that medium-firm sleep surfaces may be the most beneficial for people with chronic low back pain [7,8,11,21]. Although there is scarce evidence and lack of agreement regarding the role of the mattress in musculoskeletal pain, guidelines for prevention of low back pain, state that “there is no robust evidence for or against recommending any specific chair or mattress for prevention in low back pain, though persisting symptoms may be reduced with a medium-firm rather than a hard mattress”, [22]. There is limited evidence about mattress firmness and its effect in neck and dorsal pain. Accordingly to our results we can expect a similar improvement with MFM independently of the region of the spine.

The sleep quality in older adults is associated with several complaints, Eser et al. [23] described that 60.9% of older adults in nursing homes were poor sleepers. Similarly, we observed that our population had a comparable frequency of poor sleepers at baseline (60. 5%).

Furthermore, regarding variations in the PSQI, we did not find a significant reduction. In controversy, Jacobson et al. [21], using visual analog scales (VAS) assessed the participants perception of sleep quality and low back pain before and after setup of a new bedding system, they concluded that a middle firmness mattress increased sleep quality and reduced back discomfort. In contrast to our study, the population selected was younger and had minor musculoskeletal sleep-related pain and compromised sleep, with no clinical history of disturbed sleep [21]. Additionally, the changes in the quality of sleep for our participants could be independent of the mattress firmness, maybe due to the psychometric properties of the PSQI different from VAS; physiological changes and frequent medical comorbidities inherent of the older age group, thus these features may overshadow the benefits of the MFM in the sleep quality.

The sleep surface can contribute to the comfort of sleep [24]. The HFM and MFM have inherent physical differences, which include density and hardness. Both characteristics are important for support and comfort in order to redistribute the body weight and to reduce pressure that may cause muscle discomfort [7]. The main function of the mattress is to support the human body in a way that allows the muscles and intervertebral disks to recover [25,26].This recovery can be achieved when the shape of the spine is in its natural

physiological shape, yet with a slightly flattened lumbar lordosis due to the changed working axis of gravity [27,28]. Therefore, mechanical characteristics of the mattress should be optimized concerning both body contours and weight distribution of the sleeping person [29].Since both of these factors are highly individual, the optimal benefit in actigraphy parameters and pain reduction might be achieved with a tailored mattress, specifically designed for the physical characteristics of the participants. Although this measure might be effective, is likely to be expensive and probably non cost effective in the context of institutionalized elders.

Using various chemical formulations and processing technologies, foam firmness can be controlled during the production process, independent of the density within broad ranges. A high density foam can be produced to have low or high firmness values [30]. Similarly, the cover of the mattress is also relevant. The vinyl cover provides a more allergen-free environment during sleep [31]; however it restricts the airflow through the material, therefore the body heat will not be dispersed inducing perspiration during the night [32]. The mattress we used was a new, medium-firmness, constructed with layers of viscoelastic polyurethane and high-resilience polyurethane foams, without vinyl cover, features that could have contributed to the improvement in musculoskeletal pain.

In our study, P-VAS was steeply reduced over the duration of the study. It has been described that new mattresses require time to deliver full benefit [10], nevertheless there is no agreement of the amount of break-in time. Rosekind [33] suggested 15 nights long and others just 5 or 6 nights long [6]; moreover Scharf et al. [34] consider that only one night could be enough to adapt. Our tested mattress showed a significant result as soon the first evaluation at day 7.

In our study the improvement in musculoskeletal pain did not show a significant correlation with BMI. The literature describe that people who are overweight might be more sensitive to changes in hardness than thinner people [35]. If comfort depends on hardness, subjects with variable BMIs will need mattresses of different hardness to feel equally comfortable. Several other factors such as age, nicturia, polypharmacy and psychotropic medication, some of them with well-known impact in sleep quality had no significant correlation with the improvement in musculoskeletal pain, even though they could still impaired the quality of sleep independently [36,37,38,39].

The single night switch, evaluated with actigraphy was aimed to simulate a real admission to a geriatric inpatient unit. Our study found that the SE, in a harder mattress (HFM), had a tendency to decrease, while the SOL increase with statistically significance with a HFM. Similarly, Krystal et al. [40], in a study with actigraphy, found that a harder mattress was associated with an increased pain perception and worse sleep reports; therefore we could suggest that medium firm mattresses could be best rated.

5. Conclusions

MFM constructed with layers of viscoelastic polyurethane and high-resilience polyurethane foams may have an effect in decreasing cervical, dorsal and lumbar pain in older adults, independently of BMI, age, nicturia, polypharmacy and use of psychotropic medication, since the first week of use.

The medium firmness mattress may reduce the sleep latency since the first night of use, compared with HFM, additional studies of longer duration are recommended.

Further research is highly encouraged to find possible differences in factors affecting sleep quality between older and younger adults.

Conflicts of interest

The authors do not declare any conflicts of interest.

Disclaimer

DRIMER provided and installed the mattresses used in the trial without charge; nobody from that company participated in study design or in the collection, analysis, and interpretation of data.

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