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Better Backs by Better Beds?

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Study Design. A "randomized"/stratified, single-blinded, parallel-group study.

Objective. To evaluate 3 structurally different mattresses relative influence on patients with chronic low back pain (CLBP).

Summary of Background Data. In several advertisements, it is proclaimed that certain mattresses have a positive effect on LBP, and especially a hard mattress is commonly believed to have a positive effect.

Methods. One hundred sixty CLBP patients were randomized to 1 of 3 groups, having a mattress/bed mounted in their sleeping room for 1 month. The beds were: (1) waterbed (Akva), (2) body-conforming foam mattress (Tempur), and (3) a hard mattress (Innovation Futon). At baseline and after 4 weeks, a blinded observer interviewed the patients on LBP levels (0–10), daily function (activities of daily living, 0–30), and on the amount of sleeping hours/night.

Results. Because of dropout of 19 patients before baseline, the analyses were performed on 141 patients. During the 1-month trial period another 27 patients stopped ahead of time, which were accounted for by "worse case" as well as "no-change" analyses. Both the waterbed and the foam mattress seemed superior to the hard mattress, especially when using the probably most relevant "worst case" data. There were no relevant difference between the effects of the water bed and the foam bed.

Conclusion. The Waterbed and foam mattress' did influence back symptoms, function and sleep more positively as apposed to the hard mattress, but the differences were small.

Key words: low back pain, chronic, sleep, mattress.
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Among several factors potentially influencing the level of low back pain (LBP), mattresses are often discussed, and many patients report either advantage or disadvantage from specific mattresses.

Several believes exist on which some mattress may improve back pain more than others,[1] especially for those who have the worst pain when they wake up in the morning. The facts are unfortunately very few and inconclusive. Kovacs *et al*[2] conducted a large trial with 313 adults who had chronic low back pain. They found that a mattress of medium firmness improved pain and disability slightly among the participants compared with a more firm mattress. Otherwise there have only been made a few studies on this subject.[3–9] Most of these studies are small and weakened by shortcomings in the methods. Several are not even controlled. Furthermore, they are difficult to compare because there have been a variety of mattresses, evaluation methods, and inclusion and exclusion criteria. Although they have all indicated that some mattresses can have a positive or negative effect on back pain, no overall conclusion can be drawn.[10,11]

There are much more studies elucidating the influence on bed rest in postoperative pain or otherwise exceeding usual nightly sleep, *etc.* as an optional treatment for actual LBP ± sciatica.[11,12] That issue is, however, out of the frame of this study.

However, there are several aspects to consider when looking at the possible effects a mattress may have on LBP, especially:

- Better sleep at night leading to a greater sense of well being, which may affect the perception of pain during the day.
- The back should probably be kept more or less in a neutral position, so that long lasting end-range positions of 1 or more tender spinal joints are avoided. To obtain this demand, the mattress should be appropriately soft, conforming body curvatures by having a reasonable capacity to equalize the pressure. How close the spinal posture should mimic that of the standing posture [13] is unclear.
- The capability of easy turning from side to side to avoid a painful loaded twist in the back. An appropriately hard mattress seems optimal for this purpose.
- A specific mattress may influence intervertebral disc nutritional flow positively or negatively as a function of spinal movement, because movement affects the discal metabolism.[14–18] It is likely that the significance of this factor varies between those being sedentary or physically active during the daytime.

The purpose of this study was to investigate the relative effect as regarding back pain, leg pain, activities of daily living (ADL) and hours of sleep of respectively a waterbed, a body-conforming, visco-elastisk foam mattress, and a more firm Futon mattress on patients with chronic LBP.

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■ Materials and Methods

Patients

A total of 160 patients with largely stable chronic low back pain were included in this trial. They were primary recruited among those who had been treated in a rehabilitation unit at the Backcenter Funen, Denmark, in the period from 1996 to 2002. Those who had still pain when leaving the unit, and at the same time met the additional below-mentioned inclusion criteria, were offered to participate in this trial. This led to a total of 120 patients, while the rest had either responded to an announcement in a local newspaper or been referred from general practitioners in Funen County.

Inclusion Criteria:

- Age between 18 and 60 years.
- Daily LBP (Th12-S1) at a largely constant level for at least 6 months.
- The pain had to either dominate in the morning, or be equal to that of the rest of the day.
- Leg pain slightly stronger LBP was accepted if the above mentioned were fulfilled, and if the ratio back:leg pain was about constant.
- Exclusion Criteria:

- Other serious illness, which could influence on their sleep.
- Already having 1 of the 3 mattresses involved.

Other back pain treatment was not accepted for inclusion if started less than 3 month before entrance. However, treatment that had been going on for more than 3 months was accepted, but had to be kept at a steady-state level during the entire test period.

The Mattresses. The beds were (1) water bed (Akva), (2) body-conforming foam mattress (Tempur), and (3) a hard mattress (Innovation Futon).

The Water Bed was built in horizontal layers of fibers, enabling the water to communicate. The mattress in this study had 4 fiber layers stabilizing the water movements after 1 second.

The Tempur mattress was made of a temperature-sensitive pressure relieving material that molds to the persons shape after a few seconds.

The Futon has a foam core, surrounded by 3 layers of cotton, which makes the mattress firm, compared with the other 2 types of beds. There were no springs.

Design

A randomized (minimize allocation) single-blinded clinical trial with 3 parallel groups. After signing an informed consent, every patient had a standardized examination with both a Danish questionnaire named COBRA, and a basic physical examination including ROM and pain on specific movements, neurology, *etc*. This was used as baseline data.

The COBRA questionnaire includes the LBP rating scale[19] with, among other things, 2 11-point box scales (0–10) assessing respectively LBP and sciatica, and a 15-question scale that grades the daily function level, such as problems with carrying grossary bags, walking, (un)dressing, *etc*. (ADL, score 0–30). All were averaged over the past 2 weeks.

After the clinical examination, the patients were allocated into 1 of the 3 groups, using a stratifying program,[20] aiming to equalize the following baseline data across the 3 treatment arms:

- Age
- Sex
- Duration and severity of back problem
- Number of LBP-related days off work the in last 12 months
- The daily physical workload

To ensure that the examinators were blinded, the stratification and all further contact with the patients were made by a secretary until the end of the trial.

Each time 20 to 30 people had been enrolled they were divided into the 3 mattress groups. The individual beds were delivered to their homes and installed by a person from the respective company. In most cases they had a single bed substituted, while their partner had his/her usual one. If they had a double-mattress bed they also had a double bed for the test.

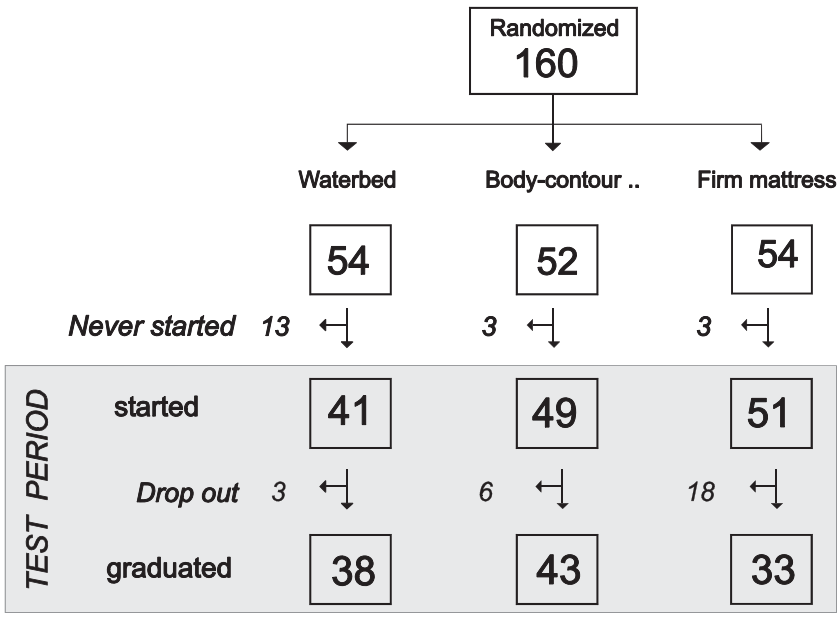

Figure 1. Flow chart through the study.

After a 1-month trial period, the test persons were interviewed again using questions identical to those at baseline, but focused towards the effect-parameter. The ones who stopped during the trial were examined by a short questionnaire, only. This made it possible to determine if the dropouts were due to the patients getting better, worse, or for some other reason.

Effect Parameters

The primary effect parameter was chosen to be LBP. In addition, we also evaluated the influence on leg pain, the functionality ADL score and on sleep.

Statistical Analysis

To compare data across the 3 groups, the Kruskal-Wallis test was used. If significance hereby was obtained, the Mann-Whitney test assessed pairwise differences. Wilcoxons test for paired data compared baseline data within each of the 3 groups with those after the trial. For elucidating a possible correlation between LBP and sleep a Spearman test was performed. To make sure that the small variations seen at baseline did not influence the results, calculations were made with the differences between data before-after.

The dropouts were accounted for by a "worse-case" and a "no-influence" analysis, meaning that for each parameter, 2 different calculations were made. One where the participants who had dropped out received the same change as those located at the worst 90% percentile of those fulfilling the study ("worst case"). We found "real worst case" (100% fractile) being unfairly poor estimates due to single-person's poor results, but selected the 90-percentile. In the other calculation were the dropouts given the same score as they had at baseline ("no-influence").

For all tests, the level of statistical significance was set to $P \leq 0.05$. SPSS version 14.0 was used for the analyses.

■ Results

Quite a large amount of test persons dropped out either before or during the trial, conf. Figure 1.

Dropouts Before Trial

The 19 participants, who never started testing a bed, were not used in the statistical material. The predominant reason for dropping out at this stage was related to the waterbed. Several test-persons dropped out due to the fact that they had some prejudice towards this type of mattress. In most cases they had never tried one themselves, but only heard negative things about it. A few patients had tried a waterbed once or a few times earlier and did not like it. The primary complaint was that they "got seasick" or woke up every time they or their partner turned around, and therefore had impaired sleep. Most importantly, no one of the patients that we know of dropped out before start because they already knew that the mattress would give them more back pain. Other reasons for never starting the mattress testing was due to practical reasons such as inability to store their usual beds during the 4 weeks, or if it was impossible to grant their wishes on double bed.

Despite the large amount of dropouts in the waterbed group, the 3 groups were comparable at baseline, irrespective they were compared with or without the early dropouts (Table 1).

Table 2. Differences in Selected Parameters From Start to End of Trial

Difference in Selected Parameters From Start to End of Trial								
M/F	12	29	19	30	19	32		
	Waterbed		Foam Mattress		Firm Mattress			
	M	IQR	M	IQR	M	IQR	*P*	*P*
LBP (0–10)	−0.4	−2.0;0.0	0.1	−1.0;1.0	0.5	0.0;1.0	Drop out = "90%" <0.001	Drop out = "0%" 0.01
Drop out *P*	90% 0.055	0% 0.008	90% 0.924	0% 0.191	90% 0.004	0% 0.790		
Leg pain (0–10)	−0.5	−1.0;1.0	−0.3	−1.0;1.0	0.4	0.0;1.0	0.001	0.072
Drop out *P*	90% 0.338	0% 0.080	90% 0.761	0% 0.132	90% 0.004	0% 0.661		
ADL (0–30)	0	−4;2	1	−2;2	2	0;2	0.003	0.3
Drop out *P*	90% 0.366	0% 0.124	90% 0.473	0% 0.539	90% <0.001	0% 0.278		
Sleep (h)	0.6	−0.5;1.0	0.3	−0.5;0.5	−0.4	−0.5;0.0	<0.001	0.02
Drop out *P*	90% 0.219	0% 0.056	90% 0.949	0% 0.204	90% <0.001	0% 0261		

The data given as "90%" are with the drop-outs during the trial tested in a worst-case analysis, whereas "no change" ("0%") refers to data, where drop outs had their baseline values repeated at follow-up.
This is also the case for the horizontally placed *P*-values, which refers to the paired tests assessing differences from baseline to 1 mo within each type of mattress. M (median) and IQR (inter-quartile range) refer to the lines with the effect variables only.

Table 1. Baseline Data of All Included (Left) and of Those Who Actually Started to Test a Bed (Right), Given by Medians (M) and Interquartile Ranges (IQR)

	Data at Baseline for All Included							Data of Patients Starting the Trial						
	Waterbed		Foam Mattress		Firm Mattress			Waterbed		Foam Mattress		Firm Mattress		
	M	IQR	M	IQR	M	IQR	*P*	M	IQR	M	IQR	M	IQR	*P*
M/F	20/34		19/33		20/34			12/29		19/30		19/32		
Age (yr)	41	35–47	42	35–54	43	37–50	0.34	41	36–49	43	37–54	42	35–50	0.67
Height (cm)	170	165–178	172	165–176	172	165–181	0.49	168	164–177	172	167–176	172	165–180	0.31
Weight	71.5	63–90	77.5	64–88	77.5	67–88	0.29	70.0	60–87	76.0	65–89	77.0	68–88	0.18
Duration of pain (yr)	4	3–10	4.5	2–10	3	2–7	0.35	4	2–8	4	3–9	3	2–9	0.48
LBP (0–10)	5.3	4–7	5.0	4–7	5.2	4–6	0.52	5.4	4–7	5.0	3–7	5.2	5–7	0.35
Leg pain (0–10)	3.2	1–5	2.9	1–5	3.0	0–6	0.72	3.8	1–5	3.1	1–5	3.6	0–6	0.52
ADL (0–30)	15	10–21	16	10–18	12	10–17	0.46	14	9–19	15	10–19	13	10–20	0.47
Sleep (h)	6.1	5.0–6.5	6.2	5.5–7.0	6.5	5.4–7.0	0.73	6.1	5.0–7.5	6.1	5.5–7.0	6.6	5.0–7.0	0.39

P-values refer to the Kruskal-Wallis test performed on the data comparing the 3 groups.

Dropouts During Trial

The majority of the dropouts stopped because they got more pain or less sleep. Three participants stopped because of practical reasons not related to LBP.

Mattress Effect

As seen in Table 2 there were statistically significant differences between the 3 groups on all variables when calculat-

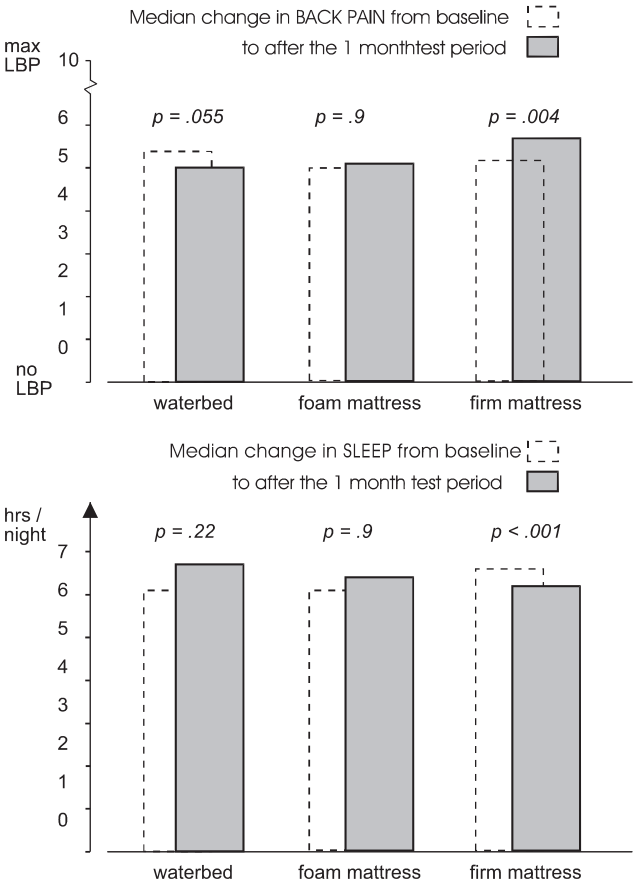

Figure 2. Effects of the three mattresses on low back pain and sleep. The *P*-values refer to before-after within each mattress, analyzed with drop-outs deemed to be as the worst 90% fractile. The differences across the beds appear from Table 2.

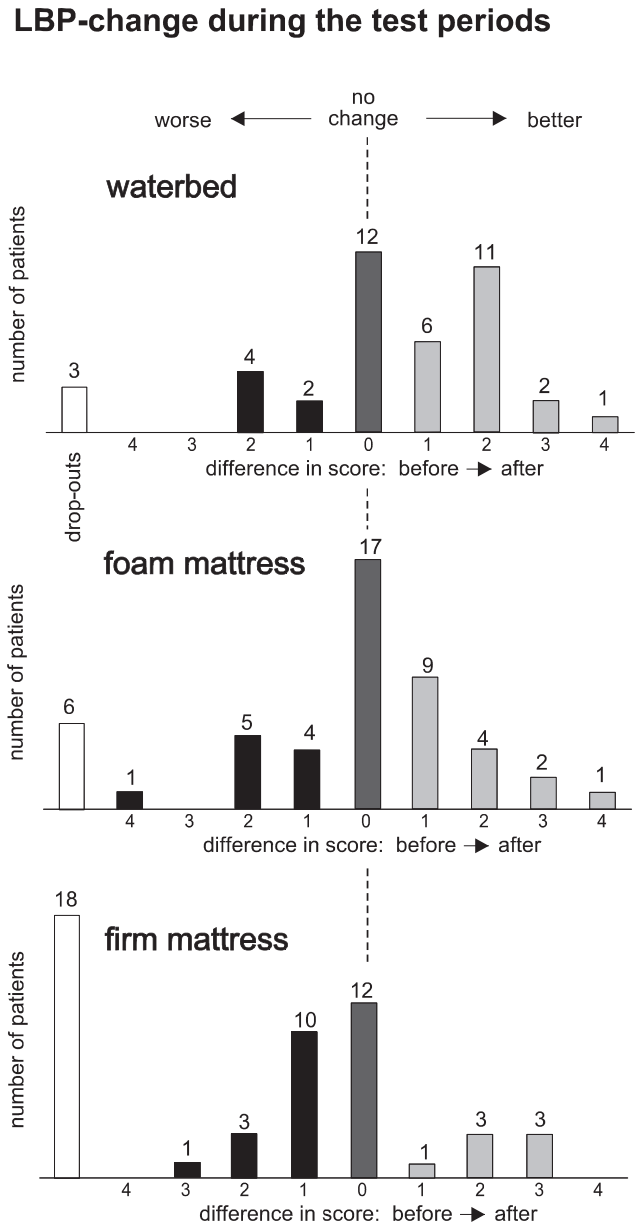

Figure 3. Number of patients that became better (right), worse (left), or remained unchanged (middle) during the 1-month test period for each mattress. Numbers of drop-outs are seen to the left.

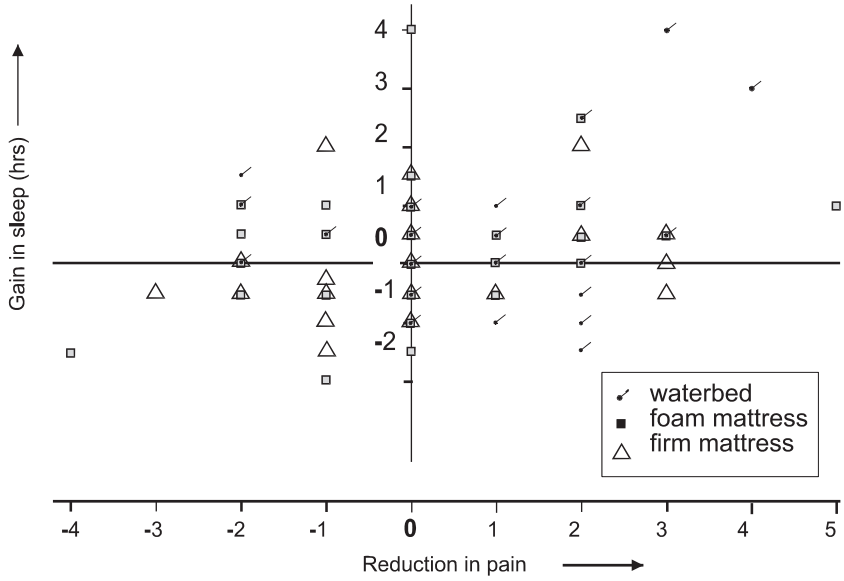

Figure 4. Correlations between reduction of back pain during the 1-month test and gain in sleeping hours. For each bed, there was only statistical significance for the firm mattress, but an overall analysis obtained statistical significance. Please note that several points reflects more than 1 person.

ing on "worst-case" data disfavoring the hard mattress. When using the "no-influence" analysis, where the dropouts were given the baseline score at follow-up, there was still statistically significant difference in LBP and sleeping hours, almost so for leg pain ($P = 0.07$), but not for ADL.

Regarding individual mattress differences, both the waterbed and the foam mattress were superior to the hard mattress when using "worst-case" data, the highest *P*-value being 0.015. If using no-influence data, the waterbed was still significantly better than the hard-mattress group regarding both LBP, leg pain, and hours of sleep, but not quite so for ADL ($P = 0.1$). The foam mattress were only significantly superior to the hard 1 with "no-change data" regarding sleeping hours ($P = 0.04$), almost so for back pain ($P = 0.06$) but not in the other parameters.

No significant differences were found between the waterbed and the foam mattress, the smallest *P*-value being between 0.12 and 0.43.

Regarding the effect in the individual groups from before to after the trial, the differences are generally small. For the hard-mattress group, the difference was, however, somewhat systematic because a statistically significant difference in all parameters was seen when using the "worst-case" analysis, pointing towards the result that the patients generally got worse with that mattress. There were no significant differences if using the "no influence" data.

In the other 2 groups there were a minor tendency that the patients in the waterbed group became better, but only with statistical significance for LBP.

The number of patients getting better or worse from baseline to end of the trial is displayed in Figures 2 and 3, where the most relevant data are illustrated. It shows that the majority of the patients who slept in either the waterbed or the foam mattress became slightly better, whereas the opposite was the case in the hard-mattress group.

Columns in Figures 2 and 3 illustrate only LBP and sleep (Figure 2), but the same tendencies were the case in all 4 effect parameters.

A possible correlation between reduction in pain and gain in sleep was also tested (Figure 4). It was not intended in advance, and was done only for a possible observation-based hypothesis. There was an overall trend for such a correlation, but neither waterbed nor foam mattress did obtain statistical significance at the Spearman analysis ($P = 0.7$ and 0.15, respectively), which did those on the hard mattress, $P = 0.007$. For the total sample, the correlation was present, $P = 0.02$.

Another *post hoc* analysis tested a possible difference in influence from the respective beds on LBP impact whether they initially belonged to the best or worst half of the patients. No such trend was seen.

■ Discussion

The dominant problem in this study is the large amount of dropouts, and how to account for these without giving 1 or 2 group an unfair preference. Because the hard mattress stands for the largest amount of test persons who stopped during the trial, this group would get a statistical advantage if these patients simply were left out of the analysis, because increased pain was the predominant reason for dropping out. On the other hand, if the dropouts were given too poor missing-data estimates, this group would probably have an unfair disadvantage compared with the 2 others.

Because of the fact that dropouts were largely caused by increased pain we found that a "worst-case" score equal to the worst 90% percentile of those fulfilling the study is a fair estimate, but there is no way we can ensure if this is the truth.

The fact that the hard mattress was disfavored even with the "no-influence" model, which is much too positive, makes it evident that this mattress generally influenced

back problems negatively when compared with the 2 softer mattresses. In each group there were, however, test persons who became better, worse, or remained unchanged, also with the hard mattress even though they generally had the poorest result. When looking at the effect within the groups, the differences were generally small.

Looking at the influence on pain, the same groups who had such a positive influence, generally had the best effect on sleep as well. This indicates a relationship between pain and sleep, but not what is "chicken or egg." The correlation was supported statistically when calculating the total amount of test persons fulfilling the study, but only statistically significantly in the Futon bed when looking at each individual group.

In this study, like in the one by Kovacs *et al*,[2] it was the softer types of mattresses who had the best results. There can be many reasons why a hard mattress is more negative than many people often have believed: If it is hard, the user will be more likely to turn around in the bed during the night, because the pressures on prominating body parts, *e.g.*, hip, shoulder, and so on, are bigger. If actual back pain is felt with such twisting movements both pain and poor sleep is registered. Regarding soft mattresses, it could be speculated that some kind of softness gives the advantage that they conform natural body curvatures to bring the joints in intermediary positions, whereas others just let the body parts sink until some joints are in an end-range or even twisted position, which may become painful over time during sleep. Because the 2 soft mattresses in the present study are largely conforming the individual body parts traced by natural pressure distribution, they may be representing the first mentioned type of softness, contrasting the softness of an, *e.g.*, old spring mattress with worn-down springs.

Moreover, it seems obvious that the more difficult it is to turn from side to side, which is especially the case in a waterbed, the more seldom it will be done during the sleep. But actually, the more even the pressure distribution, the less are such turns needed.

Thus, body-conforming soft mattresses seem to have advantage over hard mattresses. Probably they are also better than soft, worn-out spring mattresses, hammocks, and other soft types that do not conform to natural, intermediary positioned body curvatures. The last hypothesis, however, can not be drawn from this or other studies, and should be studied further.

■ Conclusion

A waterbed and a body-contour foam mattress generally influenced back symptoms, function, and sleep more positively than a hard mattress, but the differences were small.

■ Key Points

- Both the waterbed and the foam mattress influenced LBP and sleep more positively than the hard mattress.
- Because of some participants dislike of a waterbed before the study, and due to other non-LBP related aspect, several did not want to join the study although, when randomized to this bed. Several others, randomized to the hard mattress, dropped out during the trial mostly because of increased pain.
- There seemed generally to be a correlation between LBP and sleep.

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