A lumbar body support (KBS 2000) alters lumbar muscle recruitment patterns in patients with acute-upon-chronic lower back pain

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Objective. To determine the effects of a locally designed lumbar body support (LBS) on integrated electromyographic (IEMG) activity of the lumbar erector spinae muscles, on heart rate and on ratings of discomfort in patients with low back pain.

Design. Non-randomised controlled trial.

Setting. Patients referred from general practitioners and back pain rehabilitation programmes in Cape Town.

Patients and other participants. Ten patients with low back pain of diverse causes. Values were compared with those in 10 control subjects without low back pain.

Intervention. Patients and controls lay supine on (in random order) either a flat conventional mattress or a LBS placed on top of the flat mattress, for a 30-minute period (acute exposure), and every night for 2 weeks (chronic exposure).

Main outcome measures. IEMG activity of the lumbar erector spinae muscles, heart rate, and perception of comfort.

Results. IEMG activity of the lumbar erector spinae muscles did not differ between controls and patients when lying on the LBS on top of the CM after either acute or chronic exposure. However, it was significantly greater ($P < 0,05$) in patients than in controls when lying on the flat mattress. Subjective ratings of discomfort and heart rates mirrored these changes and were higher in patients only when lying on the flat mattress ($P < 0,05$). Patients with low back pain also reported that sleeping overnight on the LBS on top of their own mattress significantly reduced discomfort ratings.

Conclusions. When lying on a mattress with a flat surface, patients with chronic low back pain have higher IEMG activity of the erector spinae muscles, higher heart rates and higher subjective ratings of discomfort than do

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control subjects. These differences disappear when both groups use a specially designed lumbar body support placed on top of the flat surface. These preliminary studies suggest that a lumbar body support should be evaluated in the chronic management of low back pain.

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At least 80% of the population experiences lower back pain (LBP) before age 55,[1] yet management of the condition remains unsatisfactory, probably because of its varied causes. A precise anatomical diagnosis can be made in only 10% of cases, so the diagnosis is usually nonspecific.[2] In addition, pain of soft-tissue origin can produce symptoms similar to those of many other conditions; myofascial back pain, for example, can mimic nerve root compression.[3]

Bed rest, the use of analgesics and muscle relaxants, and the prescription of a firm mattress remain the cornerstones of current conservative management of LBP.[4] Prolonged bed rest may be contraindicated, however, because it leads to deterioration of the cardiovascular, pulmonary and musculoskeletal systems.[5]

It has also been shown that changes in sitting posture can alter LBP.[6] The use of lumbar body supports (LBS) while sitting can prevent abnormal stresses on the collagenous elements of the intervertebral discs and zygapophyseal joints,[7] preserve lumbar lordosis,[8] decrease erector spinae muscle activity,[9] and reduce LBP.[10]

While studies have examined the effect of lumbar support on LBP during sitting,[7-9] we are not aware that the effect of lumbar support in the supine position has been studied. Since patients with LBP may lie in a supine position for a considerable period each day, it is possible that the use of a lumbar body support might influence their symptoms.

The purpose of this investigation was therefore to compare the effect on patients with LBP and on healthy controls of lying supine on a specially contoured, quadruple density foam LBS (KBS 2000; Klaas Vakie, Cape Town, South Africa), on top of a flat surface mattress. Since muscle spasm and increased electromyographic (EMG) activity of the lower back muscles are recognised findings in LBP,[11] we compared integrated surface EMG (IEMG) activity of the lumbar erector spinae muscles, as well as heart rate (HR) and reported perception of comfort, in patients with LBP and healthy controls after short- and longer-term exposure to both the LBS on top of a conventional flat mattress (LBS + CM), and a CM without the LBS.

Material and methods

Ten patients (3 male and 7 female) with a history of localised LBP of various causes (Table I) were referred by general practitioners or from a back pain rehabilitation programme in Cape Town. For a patient to be included in the study, deep palpation of the lumbar erector spinae muscles or the spinous processes had to elicit pain or discomfort. Patients were not permitted to receive new or additional analgesic or anti-inflammatory medications for the duration of the trial. Their responses were compared to those of age-, sex-, and mass-matched healthy controls free of LBP, who had volunteered to take part in the study.

Table I. Patient characteristics

Patient No.	Sex	Age (yrs)	Mass (kg)	Clinical diagnosis
1	F	46	83	Myalgic encephalomyalitis
2	M	52	72	Previous bilateral spinal fusion
3	F	28	60	Scoliosis, L5 - S1 disc prolapse
4	F	30	57	Malignant myeloma
5	F	54	64	Ankylosing spondylitis, osteoporosis
6	F	33	75	Spinal fusion L5 - S1
7	M	17	92	Scheuermann's disease
8	M	59	77	Previous L3 - L4 discectomy
9	F	49	85	Multiple sclerosis
10	F	41	72	L5 - S1 disc prolapse

The study protocol was approved by the Ethics and Research Committee of the Faculty of Medicine, University of Cape Town, and performed according to the principles of the Declaration of Helsinki. All subjects provided written informed consent.

Subjects reported to the laboratory at the same time of day for each test. Standard medical and surgical histories were recorded for each patient, as were past and present symptoms, intensity of lower back pain, onset of pain, relieving factors, physical activities and present medication. IEMG activity of the lumbar erector spinae muscles was measured using a 4-channel EMG and customised software programme (EM8; Psitech, South Africa), which measured continuous skeletal muscle activity by averaging IEMG activity over 5-minute periods. IEMG activity was detected by pairs of surface electrodes (Medicotest; Olstykke, Denmark) of 5 mm diameter positioned over the muscle belly of the erector spinae muscles of each subject at the L3 - L5 level. Electrodes were placed on the side where the patient experienced the most severe pain. If both sides were equally painful, they were placed on the right hand side of the spine. Before placement of each electrode, the skin was prepared with sandpaper and swabbed with alcohol. The leads were further secured to the skin with micropore adhesive tape to prevent movement. The inter-electrode distance, measured in the longitudinal direction of the muscle fibres, was approximately 10 cm. These positions were marked using a transparent numbered grid to ensure that electrode placement was identical during each test. EMG activity was sampled 18 times per second; the IEMG signals were amplified and the data displayed on a computer screen at the end of each 5-minute period.

Patients and controls were randomised to the LBS + CM or the CM alone at the initial test. The CM was a triple-density, flat, rigid, supportive foam mattress (Fig. 1). Subjects lay supine on the LBS + CM or on the CM alone for 10 minutes before data were recorded, and then for a further 30 minutes (acute exposure). Heart rate was recorded at 5-minute intervals using a Loheimer M607 monitor (Munich, Germany) with self-adhering electrodes placed in the CM5 position. Perception of comfort was recorded on a scale of 1 to 10 (Table II) at the end of each 10-minute period.

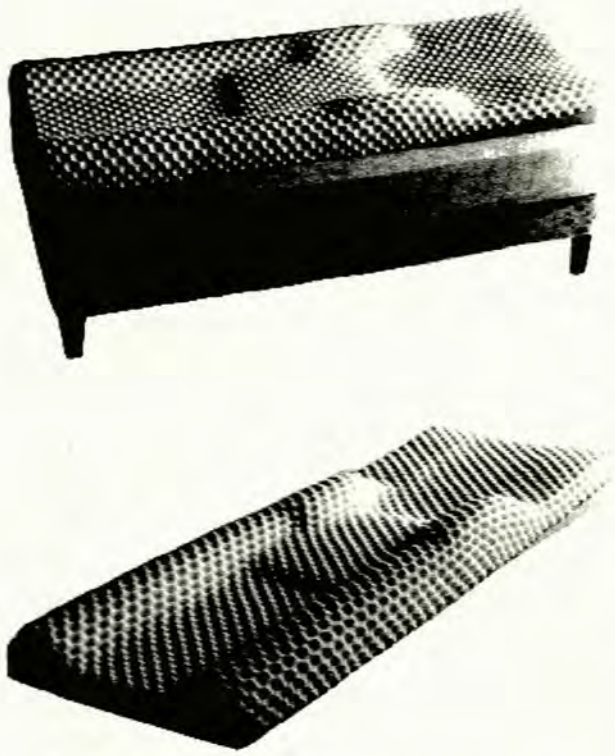

Fig. 1. Above: **lumbar body support;** below: **lumbar body support on top of conventional mattress.**

After a 10-minute break, the exact testing procedures were replicated on the other surface. Testing conditions (room temperature, investigator and background music) were constant for each test under the two trial conditions.

Subjects then took the LBS home for 2 weeks so that they could become accustomed to sleeping on it placed on top of their own mattress (chronic exposure). During this period they reported their perception of discomfort each morning and evening on the 10-point scale (Table II).

Table II. Perception of comfort/discomfort on a 10-point scale

1 = Extremely comfortable
2 = Very comfortable
3 = Moderate comfort
4 = Comfort
5 = Discomfort
6 = Mild discomfort
7 = Moderate discomfort
8 = Severe discomfort
9 = Extreme discomfort
10 = Unbearable discomfort

Statistical analysis

The significance of differences between experimental variables that were normally distributed were analysed using an analysis of variance (ANOVA) and a paired Student's *t*-test. Comparisons between controls and patients were made with the unpaired Student's *t*-test. Data that were not normally distributed were analysed using the Wilcoxon signed-rank test. Statistical significance was established at the $P < 0,05$ confidence level. Statistical procedures were performed on Statpak (Northwest Analytical Inc., Portland, Oregon, USA).

Results

The conditions causing the patients' back pain are listed in Table I. Seven females and 3 males (mean age (±SE) 41 ± 4 years, mean mass 73 ± 3 kg) with LBP and 7 female and 3 male controls (mean age 35 ± 4 years, mean mass 67 ± 4 kg) participated. All patients and controls completed the study.

IEMG activity of the lumbar erector spinae muscles

IEMG activity of the lumbar erector spinae muscles, measured at 5-minute intervals during supine exposure to both the LBS + CM and the CM, is shown in Figs 2 and 3. IEMG activity was not significantly different in control subjects when resting on the LBS + CM or the CM during either the acute or the chronic exposure tests (Figs 2 and 3), and values in control subjects did not differ from those in patients with LBP when lying on the LBS + CM during either acute (Fig. 2) or chronic (Fig. 3) exposure. However, IEMG activity was significantly reduced in patients with LBP on the LBS + CM compared with the CM after 20 minutes ($P < 0,05$) during acute and after 15 minutes during chronic exposure to the LBS. There were no significant differences in the responses of the patient group to acute or chronic exposure on either surface.

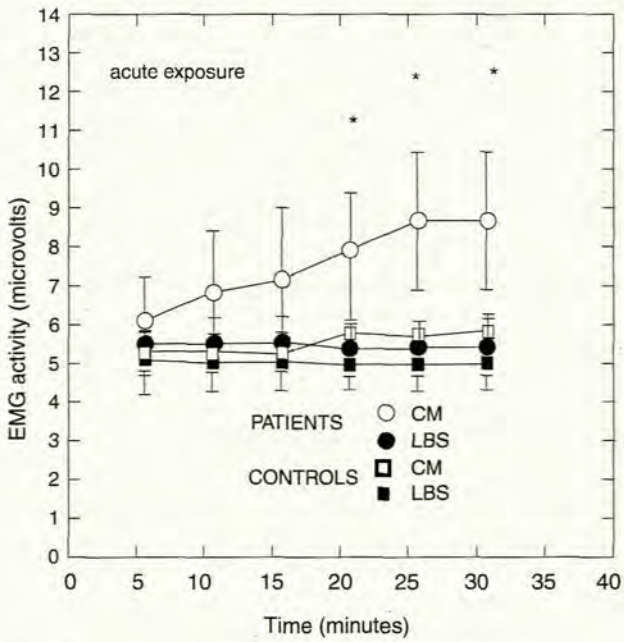

Fig. 2. Changes in IEMG activity (mean ± SE) of the lumbar erector spinae muscles during 30 minutes in the supine position on either the CM or the LBS + CM (acute exposure). * = $P < 0,05$ patients-CM v. patients-LBS.

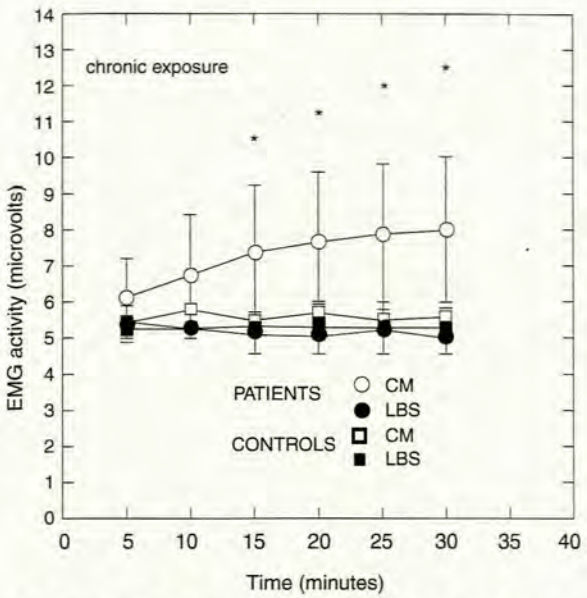

Fig. 3. Changes in IEMG activity (mean ± SE) of the lumbar erector spinae muscles during 30 minutes in the supine position after nightly exposure to the LBS for 2 weeks (chronic exposure). * = $P < 0,05$ patients-CM v. patients-LBS.

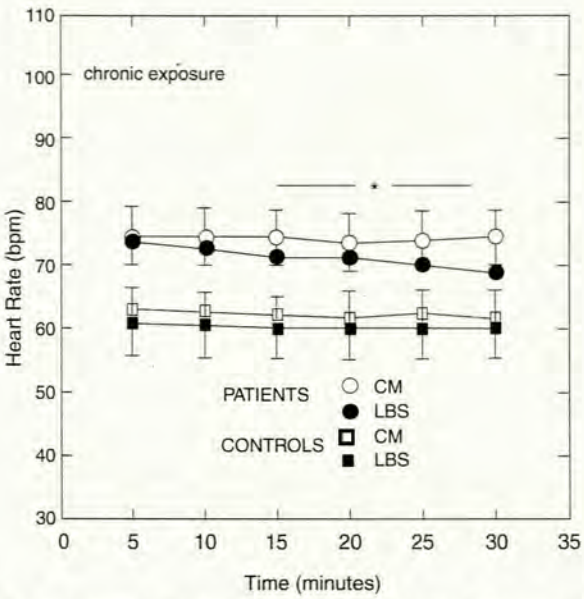

Fig. 5. Changes in heart rate (mean ± SE) during 30 minutes in the supine position after nightly exposure to the LBS for 2 weeks (chronic exposure). * = $P < 0,05$ patients-CM v. patients-LBS.

Heart rate

Heart rates during the tests are depicted in Figs 4 and 5. Although heart rates tended to be higher in patients with LBP, there was no difference in heart rate between patients and controls on the LBS + CM or the CM throughout either the acute (Fig. 4) or the chronic (Fig. 5) exposure test. However, heart rates of patients with LBP rose significantly after 15 minutes of lying on the CM ($P < 0,05$) in both the acute (Fig. 4) and the chronic tests (Fig. 5). Heart rates were unchanged in patients while lying on the LBS + CM. The heart rate in controls was the same when lying on either the LBS + CM or the CM.

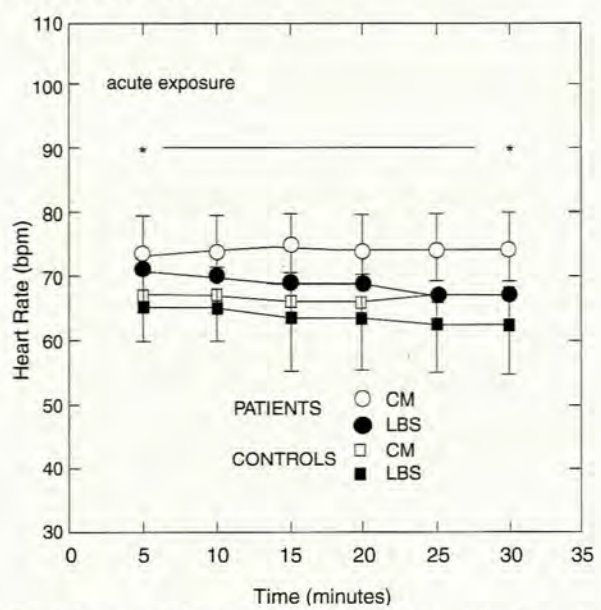

Fig. 4. Changes in heart rate (mean ± SE) during 30 minutes in the supine position on either the CM or the LBS + CM (acute exposure). * = $P < 0,05$ patients-CM v. patients-LBS.

Rating of discomfort during the test

Changes in ratings of discomfort measured on the 10-point scale during the tests are listed in Fig. 6. There were no significant differences in ratings for patients and control subjects when lying on the LBS + CM after either acute or chronic exposure. In contrast, ratings were significantly higher in patients and control subjects when lying on the CM ($P < 0,05$) compared with the LBS + CM. Furthermore, ratings were also significantly higher in patients than in control subjects when lying on the CM after both acute and chronic exposure ($P < 0,001$).

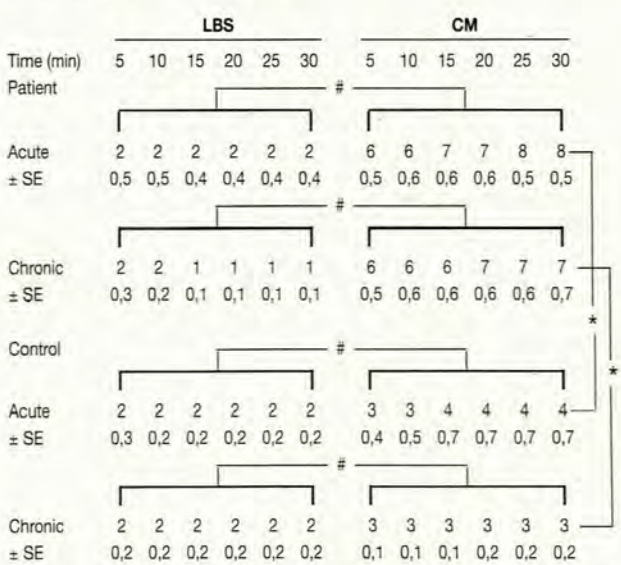

Fig. 6. Ratings of comfort (10-point scale) (mean ± SE) during 30 minutes of lying supine on the LBS and the CM, and after chronic exposure to the LBS. • = $P < 0,001$ patient v. control; # = $P < 0,05$ LBS v. CM.

Rating of discomfort over the 2-week period

Mean ratings of discomfort on the 10-point scale each morning and evening over the 2-week period are shown in Fig. 7. Values reported by patients were significantly higher in the evening than in the morning ($P < 0,001$), and were also significantly higher than the corresponding values in the control subjects ($P < 0,001$). Evening and morning values were not significantly different in the control subjects.

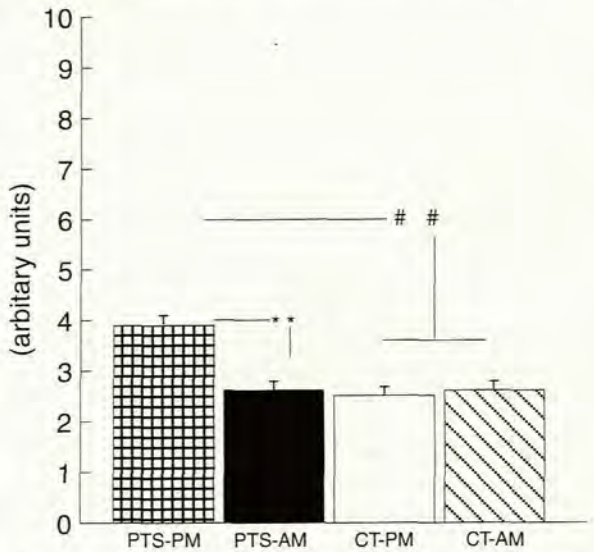

Fig. 7. Effect of sleeping on the LBS + CM for 14 consecutive nights on ratings of discomfort (10-point scale) (mean ± SE) in the morning and evening (PTS = patients; CT = controls, PM = evening, AM = morning). ** = $P < 0,01$ PM v. AM.

Discussion

The most important finding of this study was that both control subjects and patients with low back pain reported that lying on the LBS + CM was more comfortable than lying on the CM. Indeed, when lying on the LBS + CM levels of discomfort reported by patients with LBP were the same as those of the control subjects. In contrast, patients with LBP reported significantly higher levels of discomfort than did controls when lying on the CM.

Furthermore, discomfort increased progressively in the patients with LBP when lying on the CM. Although ratings of discomfort tended to increase over time in the control group, the subjects did not report experiencing actual discomfort. When lying on the LBS + CM, the much lower levels of discomfort either remained the same or were reduced in both patients and controls.

These subjective responses were mirrored by changes in IEMG activity of the erector spinae muscles. IEMG activity was the same in patients and controls when lying on the LBS, but was significantly increased in patients with LBP compared with controls on acute exposure to the CM, as well as on the CM after chronic exposure to the LBS.

This finding indicates that tonic activity of the erector spinae muscles is chronically increased in patients with LBP when lying on the CM, but that this activity decreases when they rest on a LBS. It seems reasonable to assume that this increase is responsible for their progressively increasing discomfort when lying on a CM.

That IEMG activity increased significantly in patients with LBP during only 30 minutes' exposure to the CM, whereas it remained the same or fell when they lay on the LBS + CM, suggests that the true value of this body support is probably underestimated by this study. Indeed, patients reported less discomfort in the mornings after sleeping on the LBS for 2 weeks (Fig. 6). Since IEMG activity in patients decreased to normal values within 30 minutes when lying on the LBS + CM, the long-term effects of sleeping with this body support are likely to be even more pronounced.

Heart rate changes mirrored these different responses in IEMG activity and the reported ratings of discomfort in subjects lying on the different surfaces. This suggests that the increased IEMG activity was associated with either increased sympathetic or reduced parasympathetic activity.

Other studies have found that lumbar support reduces back and leg pain[6] and maintains lumbar curvature with less discomfort and reduced erector spinae activity[8] during sitting. Our study extends these findings to the use of a LBS by patients with LBP when lying down. It suggests that resting on a CM may not be the optimal form of treatment for patients with LBP, and that they should instead use a LBS, which may decrease activity of the lumbar erector spinae muscles and reduce their symptoms.

Conclusion

This study showed that compared with a CM, resting on a LBS on top of a CM significantly reduced IEMG activity of the erector spinae muscles, heart rate and levels of discomfort in patients with LBP. This effect developed within 15 minutes of exposure to the LBS. These results are sufficiently positive to suggest that long-term clinical trials of the use of the KBS 2000 in the management of LBP are warranted.

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