

Lumbar Spine Orthosis Wearing

I. Restriction of Gross Body Motions

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The effects of wearing commonly prescribed low-back braces and corsets on restriction of gross body motions were investigated. A lumbosacral corset, a chairback brace, and a molded plastic thoracolumbosacral orthosis (TLSO) were studied. Four trunk movements (flexion, extension, lateral bending, and twisting) were examined in five healthy adult men when standing and sitting. All three orthoses restricted at least some gross body motion to approximately two thirds to one half of no-orthosis values. All three orthoses failed to provide restrictions of at least 10% in at least one motion. Mean motion restriction across all eight movements studied in all five subjects were largest when wearing the TLSO and least when wearing the corset. Gross body motion restrictions relieve lumbar trunk muscle and spine loads. [Key words: lumbar orthoses, trunk motion restriction, spine loads, mechanical effects]

LUMBAR SPINE BRACES AND CORSETS are used widely to treat chronic low-back pain. There is little hard scientific evidence that lumbar orthoses are clinically effective, but retrospective studies have documented, for example, device acceptance and symptom improvement reports by 30% to 80% of wearers.¹

The current study was concerned with the mechanical rather than the clinical effectiveness of orthoses. The mechanical effectiveness of a lumbar orthosis may result from spine intersegmental motion restriction, from gross body motion restriction, from decreased loads on the lumbar muscles and/or the spine, or from combinations of these. Decreased loads on the trunk structures may be due to direct load transfer (where the orthosis transmits some of the load that otherwise would be carried by the lumbar trunk structures) or to indirect load transfer (where, for example, the orthosis—while itself transmitting little load—raises intra-abdominal pressure sufficiently to unload the trunk structures).

The effects of various orthoses on spine intersegmental motion restriction has been studied by Norton and Brown,⁷ Lumsden and Morris,⁵ Maier,⁶ Grew and Deane,³ Fidler and Plasman,² among others. Changes in intersegmental configuration produced by an orthosis may effect to some extent the distribution of loads within a motion segment, but the details of load distribution often would not seem to be as important as the total amount of load that must be distributed. Gross body motion restrictions often may be more significant than intersegmental motion restrictions in determining orthosis mechanical effectiveness. The loads on the lumbar spine in nonstrenuous tasks are determined substantially by the gross amount of trunk flexion, extension, or lateral bending, because the

structure loads serve primarily to equilibrate the moments of the upper body segments weights. An orthosis that limits upper body motions will limit the body segment weight moments, thereby reducing the loads on the lumbar trunk structures (see *Discussion* section).

This study was undertaken for these reasons. It examined three commonly used, standard-form orthoses: a lumbosacral corset, a chairback brace, and a molded plastic thoracolumbosacral orthosis (TLSO). Their effects on restricting gross body movements in five healthy adult men were measured. If a range of motion when wearing an orthosis was less than that when not wearing one, the orthosis restricted that motion.

MATERIALS AND METHODS

Five male university students with no history of significant back pain were tested. Their ages ranged from 21 to 36 years (mean: 27.1 years), their heights from 173 to 198 cm (mean: 182 cm), and their weights from 68 to 91 kg (mean: 78.5 kg). Each subject was custom-fitted with each orthosis by an experienced orthotist.

Subject testing was done in two sessions, each lasting up to 2 hours. Subjects rested 10 minutes halfway through each session. For each subject there were four test situations: wearing no orthosis, wearing the lumbosacral corset, wearing the chairback brace, and wearing the TLSO. The no-orthosis situation was always examined first, but the order in which the orthoses were examined was unique to each subject.

To measure gross body motion, balsa wood rods were fastened over the subject's abdomen and on his back at the level of the third lumbar vertebra (Figure 1). If an orthosis was worn, these rods were fastened to the orthosis at the L3 level. Two additional rods, extending laterally, were fastened to his shoulders. A marker was placed on the subject's chest over the xiphoid process. Subject movements in three planes were recorded by cameras fitted with wide-angle lenses: one camera was located approximately 1 meter above the subject's head (for transverse plane measurements), one 2.5 meters to his left (sagittal plane), and one 2.5 meters in front of him (frontal plane). Left camera observations of the abdomen and back markers were used to quantify flexion and extension movements (Figure 2). Front camera observations of the abdomen and xiphoid process markers were used to quantify lateral bending motions. Overhead camera observations of the shoulder markers were used to quantify twisting movements, while the abdomen and back markers showed what part of the twisting motions occurred above the L3 level.

First without an orthosis and then wearing each of the orthoses, the subjects performed 35 tasks in which they were asked to move maximally. Movements in flexion, extension, right and left twisting, and right and left lateral bending were included. Combination movements also were performed. In these, the subjects were asked to twist maximally and then, while holding the twist, to flex or extend maximally, or to flex or extend maximally and then to twist maximally. Although these motion combinations were examined, the results presented here include only the first movement of any combination. Thus for each subject, wearing each orthosis or no orthosis, both standing and sitting, there were at least six twisting, two lateral bending, three flexion, and three extension perfor-

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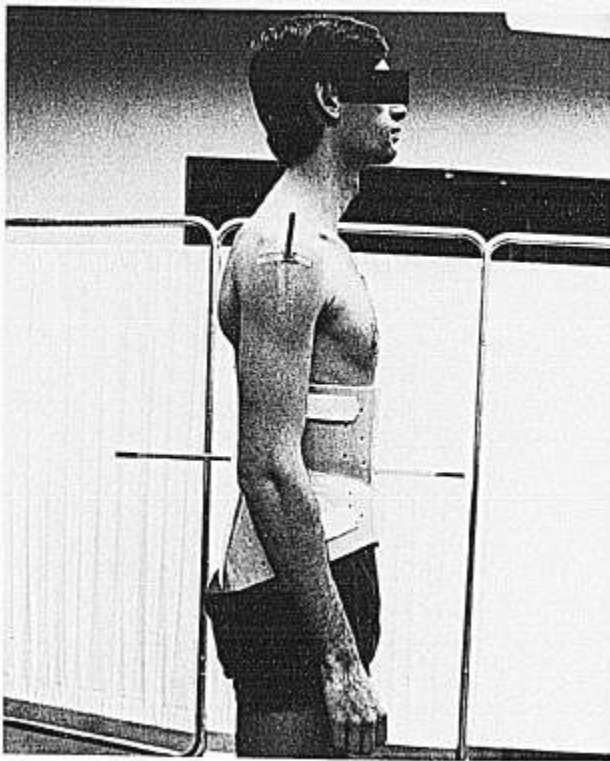


Fig 1. Abdomen and back markers for the gross motion test.

mances. For twisting and lateral bending, there were an equal number of right and left movements. Fifteen of the tasks were performed standing with the pelvis strapped to a support board, 15 were performed seated on a backless bench with the upper thighs strapped to the seat, and the five seated tasks involving extension movements were repeated with a back support 21 cm above the level of the seat.

The degree of effectiveness of an orthosis in restricting gross body movement was calculated for each subject, motion, and orthosis condition, in both standing and sitting positions. In this calculation, the mean of the motions over the relevant trials was used. The percent difference between the mean amount of motion present with and without orthoses was calculated according to:

$$\text{percent restriction provided} = \frac{(\text{no-orthosis value}) - (\text{orthosis value})}{(\text{no-orthosis value})} \times 100$$

The calculations were then averaged across the five subjects.

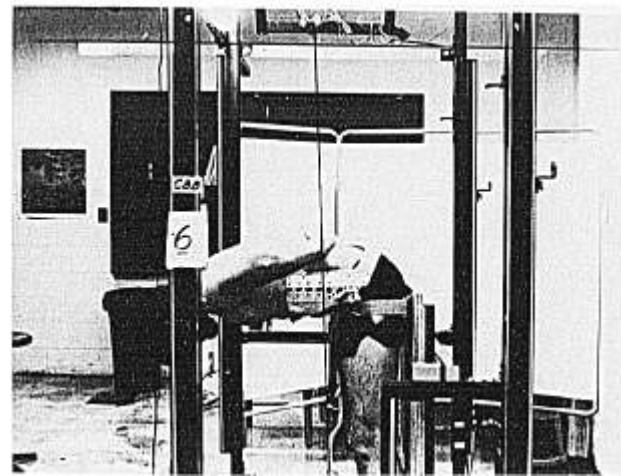


Fig 2. Use of markers to quantify flexion movements.

RESULTS

Motions up to 120° were observed, and the data showed considerable variation (Table 1). In seated extension, two subjects were observed to extend from the waist while the other three extended from the hips, but no other quantitative differences in movement were observed. The mean motions over the group of five subjects for the various modes of movement varied from 19° to 103° (Table 2).

All three orthoses were effective in restricting at least some of the gross body motions examined (flexion, extension, lateral bending, and twisting), and none permitted any notable mean increases over no-orthosis values (Table 3). All three orthoses were most effective in restricting lateral bending while seated. The mean restriction provided there by the lumbosacral corset was 29%, by the chairback brace 45%, and by the TLSO 48%. The TLSO was equally effective in restricting extension when seated using a back support, where it also provided a mean restriction of 48%.

The percentage restriction data for the various modes of motion (Table 3) show that for twisting, lateral bending, extension and seated flexion, the TLSO was the orthosis most effective in restricting gross body motion, and the lumbosacral corset usually the least effective. For restricting flexion when standing, the lumbosacral corset was most effective. If mean percent restriction over all eight modes of motion is of concern, then the TLSO was approximately

Table 1. Ranges of Motion Observed (°)

| Motion | Wearing no orthosis | Wearing LSC* | Wearing CBB† | Wearing TLSO‡ |
|------------------------------|---------------------|--------------|--------------|---------------|
| Standing | | | | |
| Twisting§ | 50-80 | 33-74 | 30-45 | 25-42 |
| Lateral bending§ | 24-52 | 16-38 | 16-32 | 9-30 |
| Flexion | 90-112 | 76-100 | 83-104 | 78-120 |
| Extension | 25-50 | 24-45 | 17-40 | 18-31 |
| Sitting | | | | |
| Twisting§ | 32-77 | 38-72 | 15-55 | 26-51 |
| Lateral bending§ | 20-50 | 19-34 | 1-33 | 2-30 |
| Flexion | 56-73 | 60-68 | 62-65 | 40-63 |
| Extension, no support | 39-100 | 25-101 | 31-93 | 18-76 |
| Extension, with back support | 30-48 | 17-41 | 9-40 | 8-29 |

*LSC = lumbosacral corset.
 †CBB = chairback brace.
 ‡TLSO = thoracolumbosacral jacket.
 §Includes both right and left motions.

Table 2. Mean Motions (°)

| Motion | Wearing no orthosis | Wearing LSC* | Wearing CBB† | Wearing TLSO‡ |
|------------------|------------------------|-----------------|-----------------|------------------|
| Standing | | | | |
| Twisting§ | 61 | 50 | 38 | 33 |
| Lateral bending§ | 37 | 29 | 24 | 22 |
| Flexion | 103 | 89 | 93 | 94 |
| Extension¶ | 36 | 31 | 30 | 25 |
| Sitting | | | | |
| Twisting§ | 54 | 53 | 43 | 41 |
| Lateral bending§ | 37 | 26 | 19 | 19 |
| Flexion | 65 | 65 | 63 | 52 |
| Extension¶ | 38 | 28 | 28 | 20 |

*LSC = lumbosacral corset.

†CBB = chairback brace.

‡TLSO = thoracolumbosacral jacket.

§Includes both right and left motions.

¶Seated extension values are with a back support.

twice as effective as the lumbosacral corset, with the chairback brace of intermediate effectiveness.

DISCUSSION

This study examined the mechanical effectiveness of three commonly used lumbar orthoses only in terms of the restriction of upper body gross motions that they provide, and only in healthy subjects. The devices did provide restrictions of up to 20% in flexion, and up to approximately 45% in twisting, lateral bending, and extension.

Restriction of upper body gross motions can provide relief of the loads placed on the lumbar spine and the lumbar trunk muscles. In nonstrenuous exertions, those loads are determined largely by the need to equilibrate the moments created by the overhang of the weights of the upper body segments (for example, Schultz et al⁸). When motions are restricted, those overhangs are smaller so the moments and their concomitant spine compressions and back muscle tensions requiring equilibration are less.

To gauge the magnitude of the load relief that might be provided by motion restriction, consider the case of trunk flexion. A simple biomechanical analysis of sagittally symmetric flexion (Figure 3) shows that the net flexion moment, M_{L5} , that needs to be equi-

brated at the L5 level of the trunk is related to the angle flexion θ through

$$M_{L5} = (tW_T + sW_A + hW_H) \sin \theta \quad (1)$$

where t , s , and h are the distances from L5 to the trunk, shoulders, and head, respectively, and W_T , W_A , and W_H are the weights of the trunk above L5, the two arms, and the head and neck, respectively.

Using representative data, the net flexion moment imposed by 90° of upper body flexion is approximately 45 nm (Table 4). If orthosis wearing restricts the flexion angle to 60°, this moment would be 14% smaller, and if the flexion angle is restricted to 30°, 50% smaller than its 90° value. If equilibration of these moments is achieved in a relaxed manner and intra-abdominal pressure provides no substantial relief of the flexion moment (Lantz and Schultz⁴ discuss these issues), reductions of spine loads and muscle contraction forces would be similar.

If load relief is in fact a major goal of orthosis wearing, then upper body gross flexion is probably the motion that needs restriction most. Ranges of motion in lateral bending and extension are much smaller than those in flexion (Table 2). Moreover, the loads that these motions impose on the spine for a given amount of motion are smaller, because the muscles that equilibrate the moments

Table 3. Mean Restriction Provided (percent)

| Motion | Standing | | | Sitting | | |
|---------------------------|----------|-----------------|-------|---------|----------------|------|
| | LSC* | Wearing CBB† | TLSO‡ | LSC | Wearing CBB | TLSO |
| For Each Mode of Motion | | | | | | |
| Twisting§ | 17 | 36 | 46 | -2 | 16 | 21 |
| Lateral bending§ | 22 | 37 | 42 | 29 | 45 | 48 |
| Flexion | 15 | 9 | 8 | 1 | 3 | 20 |
| Extension¶ | 9 | 12 | 23 | 28 | 27 | 48 |
| Mean over the eight modes | | | | | | |
| LSC | 15 | | | | | |
| CBB | 23 | | | | | |
| TLSO | 32 | | | | | |

*LSC = lumbosacral corset.

†CBB = chairback brace.

‡TLSO = thoracolumbosacral jacket.

§Includes both right and left motions.

¶Seated extension values are with a back support.

||Two large increases in motion skewed the mean value for the group; the CBB was the orthosis least effective in restricting extension for four of the five subjects.

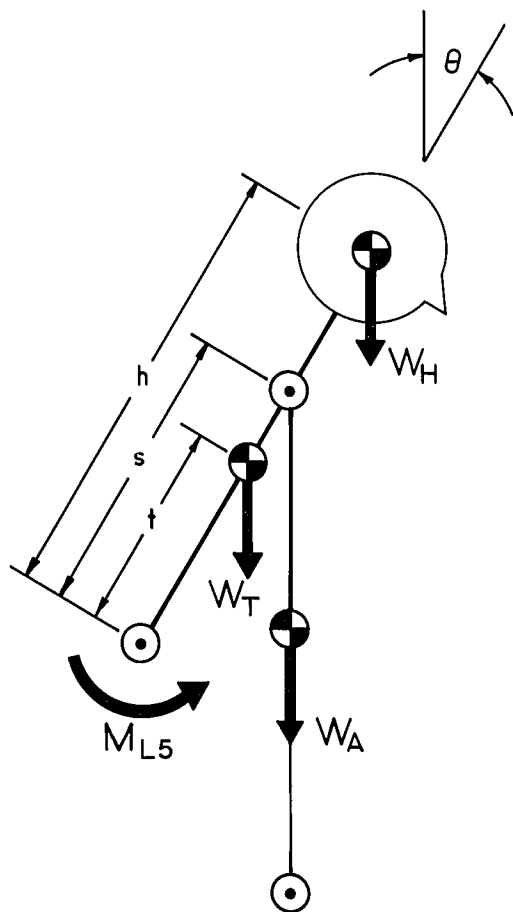


Fig 3. Schematic diagram used in calculating the load relief caused by restriction of flexion motion.

those motions create are more distant from the spine. Twisting motions by themselves load the lumbar trunk structures little.⁸ All three devices tested here restricted gross flexion more poorly than they restricted the other three motions. The lumbosacral corset, which of the three devices provided the least overall motion restriction, provided the most restriction of flexion when standing.

CONCLUSIONS

Based on these findings, we conclude that: 1) Restrictions of upper body gross motions very likely relieve the loads placed on the lumbar trunk muscles and the lumbar spine by performance of daily activities. 2) The three lumbar orthoses studied here restricted

Table 4. Net Flexion Moment at L5 Related to the Angle of Trunk Flexion

| Flexion angle° | Net flexion moment (nm) |
|----------------|-------------------------|
| 0 | 0 |
| 30 | 22.4 |
| 60 | 38.4 |
| 90 | 44.4 |

*The moments are calculated from Equation 1 using the following representative values: $W_T = 280$ N; $W_A = 63$ N; $W_H = 35$ N; $t = 25$ cm; $s = 35$ cm; and $h = 55$ cm.

at least some motions and increased none of them in five healthy young adult male wearers. 3) Restrictions of up to 20% were achieved in flexion, and restrictions of up to 48% were achieved in extension, lateral bending, and twisting.

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