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Lumbar corsets: Their effect on three-dimensional kinematics of the pelvis

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Abstract—Lumbar corsets have been recommended for low back pain patients as a way of stabilizing the lumbar region, facilitating flexion movements, and reducing pain. However, little is known about how these devices affect lumbar motion. To determine the degree of changes in the lumbar region, our approach was to quantify three-dimensional kinematic data of the pelvis in harness-supported treadmill walking. Twelve healthy subjects (age=32±11.8 years) walked on a motorized treadmill at 4.5 km/h with and without wearing a lumbar corset. Three external markers overlying the sacrum were tracked by three ultrasound microphones, determining a local coordinate system, to obtain pelvic motions in the frontal, sagittal, and transverse planes. Raw kinematic data were low-pass filtered and normalized relative to the right heel strike. Mean values for net angular displacements of the pelvis were calculated for each plane within the 5th and 95th percentile. The Student's *t*-test demonstrated significant differences ($P<0.001$) between the corset/no-corset conditions in the frontal plane. An average 40% decrease in the relative pelvis up- and downward movement occurred in the frontal plane (4.1°±2.9° vs. 7.1°±3.3°). The analysis revealed no significant differences of net angular displacements in the sagittal (2.9°±1.4 vs. 3.4°± 1.7°) and the transverse planes (4.4°±2.6° vs. 4.3°±2.1°).

Key words: *clinical gait analysis, lumbar corsets, spine kinematics.*

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INTRODUCTION

Low back pain is a costly and often seriously disabling condition. Strategies to prevent back injuries are an important public health issue. Lumbar supports, covering the abdomen and the low back, are commonly fabricated from soft elastic material with rigid support from metal stays or plastic inserts. Supports are frequently used in the management of low back pain by stabilizing the lumbar region, facilitating flexion, and reducing pain. However, the mechanisms by which lumbar supports might influence low back problems remain debatable.

Several investigations of the benefits and limitations of lumbar supports (1,2) and biomechanical studies on the effects of various orthoses on abdominal pressure, lumbar intervertebral disk pressure, and intervertebral translations during defined movements, e.g. full spinal flexion and extension (3–8) have been reported. Most biomechanical studies have been performed under static or quasi-dynamic conditions, which do not represent usual daily life routines. Biomechanical analysis should also focus on the assessment of orthoses in more functionally oriented test settings such as walking. Although pelvic movement is integral to gait (9–11), to our knowledge no attempts have been made to analyze the effects of lumbar orthoses on lumbar spine oscillations in gait.

Thus, the current study was planned to determine the degree of changes in the lumbar region during harness-

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supported walking, quantified by three-dimensional, kinematic data of the pelvis.

SUBJECTS AND METHODS

Twelve healthy subjects (8 men, 24 to 32 years old and 4 women, 29 to 33 years old) participated in the study. Each of them was screened by a clinician with musculoskeletal expertise and a subjective questionnaire (Oswestry-Disability-Score). Volunteers had no history of low back pain, or central nervous or neuromuscular disorders, and were able to perform painless trunk flexion and extension within normal limits. Left- and right-leg length measured from the floor to the trochanter major in shoeless standing did not show more than 1-cm inequality. Volunteers demonstrating body mass indices exceeding 25.0 kg/m^2 were excluded from further data analysis. Subjects walked on a motorized treadmill (HP-Cosmos®, Germany) at 4.5 km/h both with and without wearing an inflatable elastic lumbar corset (Sporlastic®, Germany) (**Figure 1**). A three-dimensional ultrasonic movement analysis system (Zebris CMS 70®, Germany) was used to track three external ultrasonic plate-mounted markers with an accuracy better than 0.6 mm (12). Spatial marker positions (x, y, z) were derived by triangulation and used for calculation of net angular displacements of the pelvis in all anatomical planes. The marker plate was fixed with double-sided adhesive tape on the skin overlying the sacrum (S1), and a belt was passed around the lower torso. The lumbar device was individually fitted to each subject and secured firmly. It extended from the lower-thoracic level to the mid-part of the sacrum posteriorly and from around the lower ribs to below the level of the anterior superior iliac spines laterally. The center of the inflatable portion of the corset was located over the spinous process of the fifth lumbar vertebra. The order of corset/no-corset trials was randomized for all participants. Prior to treadmill walking the anatomical orientation of the pelvis was defined as zero during motionless standing for computing relative angular movement. Right heel strike was determined by footswitch signals and used to define the startstop of each cycle and to calculate cycle durations. Data were sampled at 50 Hz, monitored in real time and stored on a PC for later offline analysis.

Kinematic data were optically controlled and movement artifacts were excluded from further analysis. After data acquisition, net angular displacements for the three anatomical planes were low-pass filtered (critical damped, 2nd order, double pass, 8-Hz cut off) and normalized with regard to the stride time (0–100 percent). Averaging of stride cycles was applied at two levels: I - intra-individual displacement angles were averaged on the basis of at least 20 gait cycles; II - inter-subject angular displacement average across all subjects were calculated. Mean values for net angular displacements of the pelvis were calculated for each plane within the 5th and 95th percentiles.

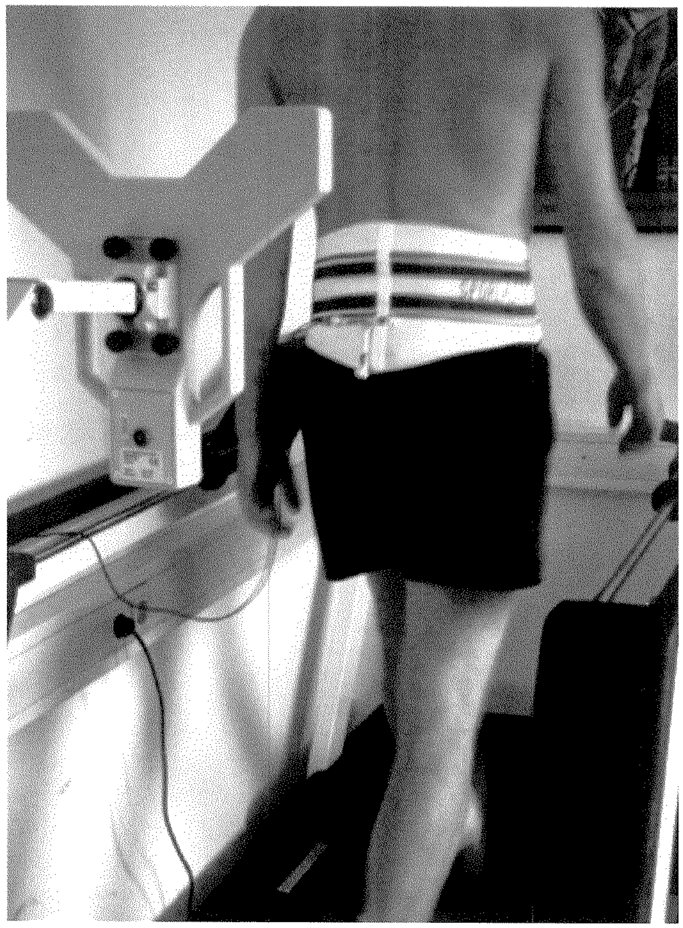

Figure 1.
Subject wearing elastic lumbar orthosis during treadmill ambulation.

Cross-correlation values were used for comparison of the time history of the inter-individual signals in all anatomical planes. Student's *t*-tests for paired samples were performed for statistical analysis of differences in amplitude parameters. This analysis was also chosen to determine differences in stride cycle duration between trials. $P<0.05$ was regarded as significant.

RESULTS

No statistical difference exists in mean cycle duration between test conditions (1.02±0.08 s *versus* 1.01±0.03 s). Student's *t*-test for paired samples demonstrated significant amplitude differences ($P<0.001$) between the corset/no-corset conditions in the frontal plane (**Figure 2**). An average 40 percent decrease in the relative pelvic motion in the frontal plane (4.1°±2.9° *versus* 7.1°±3.3°) recurred. No significant differences were found for net angular displacements in the sagittal and the transverse planes. Cross-correlation values ranged from $r=0.87$ to $r=0.99$ ($P<0.001$), demonstrating almost identical time histories of falling and rising trends between back-supported and free walking (**Figure 3**).

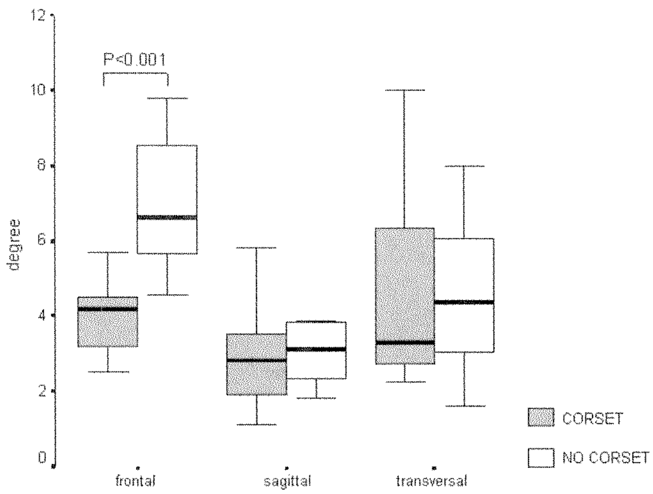

Figure 2.
Boxplot of group range of motion in all anatomical planes in the corset/no-corset condition.

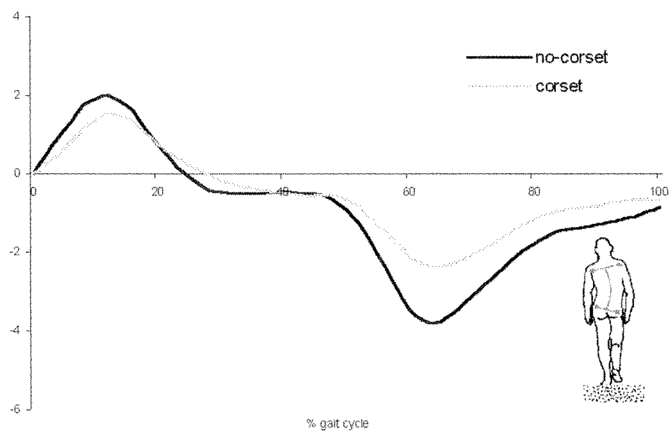

Figure 3.
Comparison of group profiles in the frontal plane during the corset/no-corset condition.

DISCUSSION

The findings confirm the synchronized interaction of pelvic and lower-limb movements in gait, demonstrating the relevance of lumbar spine and pelvic kinematics in clinical gait analysis as shown by Thurston et al. (13) and Rowe et al. (14).

The pelvic curves reveal very similar temporal patterns of rising and falling angular displacement trends in both harness-supported and free walking. Nevertheless, the results provide strong evidence that the passive support mechanism of lumbar orthoses can be effective in reducing the range of pelvic oscillations in the frontal plane. These decreased pelvic side flexions are consistent with previously reported research results by Lantz et al. (15) and Buchhalter et al. (16) and probably are based on the increased stiffness of the lumbar torso in the frontal plane caused by the orthosis according to McGill et al. (17). It appears that elastic lumbar supports have no significant effect on the magnitude of angular displacements of the pelvis in the sagittal and transverse planes during walking. There was a tendency toward limited movement amplitudes in the two latter planes; this trend was not statistically significant, possibly because of the limited number of subjects in this study. These findings correspond to those of Axellson et al. (18), who described weak influence on transverse and sagittal intervertebral translations in roentgen stereophotogrammetric analysis and Helliwell et al. (19), who reported a completely unaffected range of sagittal lumbar movement by subjects wearing a corset. Million et al. (4) postulated that the restriction of spinal motion by orthoses seemed to be a mechanism to relieve symptoms in low back pain patients. Additionally, Lantz et al. (15) supposed that the main part of motion restriction in orthosis wearing should be generated in the sagittal plane to realize sufficient load relief of the lumbar spine. It is likely that the design of the test corset accounted in part for the motion limitation; so in order to achieve a significant reduction of the angular displacements in the sagittal and transverse planes, lumbar orthosis construction should be improved as recommended by Lüssenhop et al. (20). Furthermore, corsets of varying designs probably will yield different results evn by skin stimulation in differential body segments, i.e., variation of the proprioceptive effect by means of modification of the corset construction. So both different types of orthoses and different structures (rear, front, or side part) of the same corset may cause various, absolute, and/or relative motion restrictions in one subject because of differential proprioception for lateral and/*versus* forward flexion or axial rotation.

One of the main effects of lumbar supports should be the reduction of lumbar lordosis. Thus, Thoumie et al. (21) showed a significant decrease of lumbar lordosis angles for continuous recordings in nurses' respective physiotherapists' workmanship. Unfortunately, simultaneous recordings of the pelvic and spine movements in the frontal and transverse planes were not conducted by the authors. However, there are only a limited number of studies concerning the effects of lumbar supports on spine posture in prolonged work-related activities. Thus future research should explore whether back orthoses can assist in three-dimensional straightening of the lumbar spine and maintain upright position of the pelvis during daily routines.

The connection between the relief of pain in low back pain patients and the wearing of lumbar orthoses as described by Million et al. (4) may be explained by other mechanisms. Several studies of pain and instability of the lower extremities indicated that the wearing of elastic lumbar orthoses improved the patients' feeling of joint stability although the corsets are unstable themselves and cannot stabilize a joint mechanically. Birmingham et al. (22) and Feuerbach et al. (23) have shown that orthoses improved the subjects' joint position sense by increasing afferent proprioceptive input via the mechanoreceptors of the skin. It can be speculated that a comparable mechanism can affect low back pain and instability or can improve restricted proprioception as has been shown recently by McNair (24).

Thus, investigation of biomechanical effects of orthoses should be complemented by neurophysiological studies. Such a mechanism may be clinically useful by promoting active back extension, improving posture, or simply increasing a subject's awareness and thus serving as a reminder to use proper movement techniques. However, at this time information is insufficient to recommend routine use of lumbar supports.

CONCLUSIONS

The amplitude of axial pelvic rotations decreased while the temporal patterns remained nearly the same in harness-supported walking compared to free treadmill walking. Elastic lumbar supports have no significant effect on pelvic kinematics in the sagittal and transverse planes. The function of orthoses should be analyzed in test conditions simulating daily activities. Future investigations should consist of rigorously controlled research on the function of lumbar supports to prevent low back pain and osteoporosis.

REFERENCES

1. Kaplan RS, Sinaki M, Hameister M. Effect of back supports on back strength in patients with osteoporosis: a pilot study. Mayo Clin Proc 1996;71:235–41
2. Gutenbrunner C, Hildebrandt HD, Gehrke A. Katamnestische Untersuchungen über die Wirksamkeit der Verordnung einer dynamischen Kreuzstützbandage bei Patienten mit chronischen Lumbalsyndromen. (Katamnesis on the effect of a dynamic lumbar orthosis in patients suffering from chronic low back pain.) Orthop Praxis 1998;34(6):383–90
3. Bartelink DL. The role of abdominal pressure in relieving the pressure on the lumbar intervertebral discs. J Bone Joint Surg Br 1957;39:718–25
4. Million R, Nilsen KH, Jayson MIV, Baker RD. Evaluation of low back pain and assessment of lumbar corsets with and without back supports. Ann Rheum Dis 1981;40:449–54
5. Norton PL, Brown T. The immobilizing efficiency of back braces; their effect on the posture and motion of the lumbo-sacral spine. J Bone Joint Surg 1957;39A:111–39
6. Lumsden RM, Morris JM. An *in vivo* study of axial rotation and immobilization at the lumbosacral joint. J Bone Joint Surg 1968;50A:1591–602
7. Nachemson A, Schultz A, Andersson G. Mechanical effectiveness studies of lumbar spine orthoses. Scand J Rehab Med 1983;9:139–49
8. Fidler MW, Plasmans CM. The effect of four types of support on the segmental mobility of the lumbosacral spine. J Bone Joint Surg 1983;65A:943–7
9. Stokes VP, Andersson C, Forssberg H. Rotational and translational movement features of the pelvis and thorax during adult human locomotion. J Biomech 1989;22:43–50
10. Vink P, Karssemeijer N. Low back muscle activity and pelvic rotation during walking. Anat Embryol 1988;178:455–60
11. Gracovetsky S. Musculoskeletal function of the spine. In: Winters JM and Woo SLY, editors. Multiple muscle systems: biomechanics and movement organization. New York: Springer-Verlag; 1990. p. 411–37
12. Himmelreich H, Stefanicki E, Banzer W. Die Ultraschallgesteuerte Anthropometrie (UGA)—Zur Entwicklung eines neuen Verfahrens in der Asymmetriediagnostik. (Ultrasound Guided Anthropometry (UGA)— A new development for diagnosing asymmetries.) Sportverl Sportschad 1998;2:60–5
13. Thurston AJ, Harris JD. Normal kinematics of the lumbar spine and pelvis. Spine 1983;8:199–205
14. Rowe PJ, White M. Three dimensional, lumbar spinal kinematics during gait, following mild musculo-skeletal low back pain in nurses. Gait & Posture 1996;4:242–51
15. Lantz SA, Schultz AB. Lumbar spine orthosis wearing. I. Restriction of gross body motions. Spine 1986;11:834–7
16. Buchhalter D, Kahanovitz N, Viola K, Dorsky S, Nordin M. Three-dimensional spinal motion measurements. Part 2: a nonin-

vasive assessment of lumbar brace immobilization of the spine. J Spinal Disord 1989;1:284–6.
17. McGill S, Seguin J, Bennett G. Passive stiffness of the lumbar torso in flexion, extension, lateral bending, and axial rotation. Effects of belt wearing and breath holding. Spine 1994;19:696–704
18. Axelsson P, Johnsson R, Stromqvist B. Effect of lumbar orthosis on intervertebral mobility: a roentgen stereophotogrammetric analysis. Spine 1992;17:678–81.
19. Helliwell PS, Wright V. What are the indications for the use of a lumbar corset in low back pain? Br J Rheumatol 1991;30:62
20. Lüssenhop S, Deuretzbacher G, Rehder U. Optimierung des mechanischen Effekts eines Präventivmieders mittels Bewegungsanalyse. (Improvement of the mechanical effect of a preventive back support using motion analysis.) Med Orth Tech 1996;116:197–201
21. Thoumie P, Drape JL, Aymard C, Bedoiseau M. Effects of a lumbar support on spine posture and motion assessed by electrogoniometer and continuous recording. Clin Biomech 1998;13:18–26
22. Birmingham TB, Kramer JF, Inglis JT, Mooney CA, Murray LJ, Fowler PJ, et al. Effect of a neoprene sleeve on knee joint position sense during sitting open kinetic chain and supine closed kinetic chain tests. Am J Sports Med 1998;26:562–6
23. Feuerbach JW, Grabiner MD, Koh TJ, Weiker GG. Effect of an ankle orthosis and ankle ligament anaesthesia on ankle joint proprioception. Am J Sports Med 1994;22(2):223–9
24. McNair PJ, Heine PJ. Trunk proprioception: enhancement through lumbar bracing. Arch Phys Med Rehabil 1999;89:96–9

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