Low back pain sufferers: Is standing postural balance facilitated by a lordotic lumbar brace?

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Summary

Introduction: The use of a lumbar lordosis orthotic device in the treatment of discogenic low back pain could be a valuable option and rehabilitation tool. The lumbar lordosis brace has been designed to meet these requirements and acts as a reminder to the patient to maintain a physiological lumbar lordosis curvature since it comprises a vertical panel on the chest and a curved rigid shell at the back. This lumbar lordosis brace exerts the necessary degree of compression in the lumbar region and achieves correction of the sagittal plane spine balance to improve postural control of the lumbar spine. Quantitative analysis of the centre of pressure (CoP) deviations, which are necessary to maintain the standing posture helps evaluate the impact of such device on postural balance.

Patients and methods: Eleven patients suffering from lumbar pain with discopathy (seven females and four males) had to stand on a force platform with their eyes closed under two basic conditions (fitted or not with a lumbar lordosis brace).

Results: On the antero-posterior axis, the lordosis brace achieved a 6 mm CP deviation from its mean position and a 51% reduction in the mean displacement prior to the initiation of the postural control mechanisms.

Discussion: The forces applied by the lumbar lordosis brace (through compression and/or change in the spinal sagittal balance) seem to improve the quality of the patient’s balance strategy. Posturography appears as a valuable tool for in situ investigation of the postural benefits achieved when using a thoracolumbosacral orthosis in patients suffering from lumbar pain.

Level of evidence Level IV.

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Introduction

About 500,000 lumbar belts are sold each year in France in the treatment of lumbar pain [1]. Nowadays, cli-
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Most orthotic devices in pain reduction within a few weeks [4—6]. However, they do not explain which biomechanical and neuromuscular mechanisms are involved in pain reduction when using a lumbar belt. Such data would markedly improve the clinical effect of this type of device.

Proprioception participates in maintaining the standing posture by permanently regulating the centre of pressure (CoP) displacements necessary to the orthogonal projection of the centre of gravity (CoG) during the stance phase. Patients with low back pain exhibit trunk proprioceptive deficits relative to the antero-posterior axis (AP) [7—10], which affect the standing postural balance [11—14]. Therefore, patients without lordosis belt demonstrate an increase in the CoP displacements, only relative to the AP axis [15,16] along with a delayed initiation of the correction due to impairment [17,18]. Despite these significant results obtained from patients suffering from lumbar pain and without any lordosis belt, posturography, when applied to the orthopaedic treatment of the trunk, is still unexplored. Even if healthy subjects fitted with a lordosis brace in the standing [19] and sitting positions [20,21] demonstrate no significant changes in their postural stability, this tool has already proved very useful in evaluating the effects of wearing a lordosis belt in the treatment of various diseases such as scoliosis [22,23] or osteoporosis [24].

Many types of lumbar lordosis belts with various designs are available, each model demonstrating a more or less significant impact on postural balance. Therefore, if most lumbar belts have a kyphotic or neutral effect [7], some devices (Jewett braceTM, Voigt-Bähler braceTM and LordactivTM) apply mechanical stresses (posterior curved rigid shell) favourable to the restoration of a physiological lumbar lordosis. To the potential compression effect is added that induced by the modification of spinal static.

Therefore the purpose of this study is to perform in situ measurements of a lumbar lordosis belt effects on the postural parameters affected by lumbar pain: CoP displacements and time to correction initiation on the AP axis. According to our hypothesis, compression and modification of spinal sagittal static provided by the lumbar lordosis belt may improve postural control according to the AP axis in patients suffering from low back pain.

Patients and methods

Patients

Eleven patients suffering from lumbar pain were involved in this experimentation: seven females and four males (44.3 ± 8.9 years; weight: 67.3 ± 13.2 kg; height: 1.70 ± 0.1 m; mean ± standard deviation). All these voluntary adults presented with a degenerative lumbar discopathy with no sign of acute pain.

Lumbar belt

The present study was conducted using the LordactivTM (Ormihl-Danet, Villeurbanne) lumbar brace (Fig. 1), which maintains physiological lordosis with means of a frontal vertical panel and a curved rigid shell at the back [25]. The textile part of the corset is made of polyamide, PE foam, cotton, elastane and elastodiene. The rigid back part as well as the front frame is made of polyethylene, aluminium, steel and stainless steel.

Protocol

The posturographic test was performed through two randomized conditions: without lumbar belt (control) and with LordactivTM lumbar belt. Patients had to stand on a static force platform (Equi+, PF02) with their arms placed along the body and their eyes closed, while trying to minimize their body displacements. Both feet were kept parallel to each other with a 35 mm distance between the internal borders of both malleoli. Four successive tests of 64 s each (64 Hz sampling) were performed with a recovery time of 64 s between each test.

Data processing

The CoP horizontal displacements were analysed regarding the surface covered by the displacement (ellipse with a 90% confidence interval) and the mean position relative to the medio-lateral (ML) and AP axes (more or less anterior and lateralized CoP position).

Analysis of the fractional Brownian motion (fBm) was used to determine the degree of control of CoP displacements (details of the calculation method and diagrams are shown in the appendix). This method revealed two distinct mechanisms successively involved in the control of CP displacements. In the first phase, during short time intervals, this trajectory tended to be far from the previous position, which is called persistent mechanism (shown by scale’s coefficient of short latency Hc). In the second phase, during longer time intervals, this trajectory tended to move closer...
Figure 2 Band-gap diagram representing the various experimental conditions (reference (REF) and lordosis lumbar belt (CL)) and the whole measured parameters (mean and standard deviation of the sample) using the temporal analysis (higher part) and fractional Brownian motion model (lower part). The significance level is represented on diagrams (* $p < 0.05$).

Mean centre of pressure position

With the lordosis belt, the mean CoP position on the AP axis was shifted about 6 mm posteriorly relative to the control condition ($W = 52; p < 0.05$). No effect was found relative to the ML axis.

Surface covered by the centre of pressure displacements

The surface covered by the CoP displacements was not significantly reduced. However, a 37% decrease relative to the control condition was noted when using the lordosis belt (321 mm$^2$ without lumbar belt versus 229 mm$^2$ with lumbar belt).

Fractional Brownian motion analysis

The \( \Delta t \) helped determine the mean time interval between the time when the CoP is away from the reference position and the time of correction initiation. Patients wearing the lordosis belt revealed a significant 15% decrease in this time of correction relative to the AP axis in comparison with the control condition ($W = 54; p < 0.05$).

The \( \langle \Delta x^2 \rangle \) value corresponded to the CoP mean square displacement at the time of correction initiation. Wearing the lordosis belt induced a significant 51% decrease in the square displacement on the AP axis compared to the control condition ($W = 60; p < 0.01$).

The \( H_{ll} \) representing the degree of anti-persistence of the CoP trajectory increased significantly by 6% compared to the control condition ($W = 54; p < 0.05$). Moreover, no significant difference could be established regarding the \( H_{cl} \) representing the degree of persistence of the CoP trajectory. Finally, no significant statistical result relative to the ML axis could be found from the obtained data.

Discussion

The aim of the present study was to evaluate the effects of a lumbar lordosis belt on the postural parameters affected by lumbar pain. According to the results, the mean position of the CoP trajectory was slightly posterior when using the lordosis belt. In principle, such data could have explained the tendency towards reduction in the degree of displacement since effects correlated with body bending demonstrated high incidences on healthy subject balance ability [26]. However, despite statistically significant results, the degree of displacement is not high enough to explain the observed effects.

Therefore, it appears more relevant to seek for other reasons, which could account for the observed effects. The modification of control mechanisms along with reduction in the mean time intervals (\( \Delta t \)) and mean square displacements (\( \Delta x^2 \)) of transitional points appear as a more interesting track. It would mean that patients suffering from lumbar pain more rapidly correct their balance impairment when fitted with a lordosis belt. The main advantage of this strategy would be to reduce the CoP displacements and their surface. Its main drawback would be that

Statistical analysis

According to the Kolmogorov-Smirnov test ($p < 0.05$), some data were not normally distributed. Therefore the non-parametric Wilcoxon test was used to reveal possible significant differences between these two conditions ($p < 0.05$) for the whole retained parameters.

Results

All the results are shown in a band-gap diagram in Fig. 2.
a rapid correction would reduce the correction mechanism performances (as shown by the significant increase in $H_0$). Actually, there is a speed/accuracy compromise in the correction mechanisms [27]: the higher the distance, the better the control and inversely. Since a poorer control induces a higher degree of stochastic mechanisms during displacements and a larger surface covered, this could account for the low effect of these better corrective abilities on CoP displacement surface values. Moreover, since the effects are only located on the AP axis (and not on the ML axis), the impact on a global parameter such as the surface, which combines the whole horizontal displacements is reduced.

When in the static standing posture, the body can be compared, on the AP axis, to an inverted pendulum regulating the CoG position using the posterior muscular activity of the legs. Any soleus muscle impairment unavoidably disrupts the regulation of the standing posture relative to this axis [28,29]. However, this type of control requires the locking of the whole mobile part of the body in order to provide a single rigid segment. The muscle sensory-motor activity from various parts of the body is then required. The impairment of one link in the chain results in the disruption of the whole postural chain [30,31]. Therefore, structural or functional modifications of the lumbar region, even situated far from the ankle joint, would lead to postural changes [12,16,32]. The compression exerted by lumbar lordosis braces (Jewett braceTM, Voigt-Bähler braceTM and LordactivTM) associated with changes in spinal curvature could account for the observed postural modifications. Actually, compression provides supplementary sensory data, which partly compensates for the lumbar proprioceptive impairment during the repositioning activities [8,9]. It also reduces trunk muscle activity [21]. Patients suffering from lumbar pain are characterized by an increased muscular strain which may be responsible for trunk postural stability along the AP axis [16] because of its lower capacity to detect movement [33] and therefore complexifying further the corrective activity [20]. Actually, it was demonstrated that a reduced lumbar lordosis when carrying a rucksack is associated with a decrease in trunk proprioception [34]. Moreover, it has been proved that maintaining a long-term lumbar kyphosis posture affects the chest repositioning abilities [35] and could constitute a lumbar pain risk factor [36]. Since patients with discopathy demonstrate a reduced lumbar lordosis [37], restoration of this lumbar spine curvature using a lordosis belt could enhance its control. Early correction in patients fitted with a lordosis brace reduces disruptions induced by excessive CoG displacements, therefore limiting the regulating activity exerted by the CoP displacements. Such efficiency could constitute one of the contributing elements for decreased lumbar pain using a lumbar lordosis brace as reported in the literature [4—6].

To conclude, the obtained in situ data using a force platform help characterize the postural effects of a lumbar lordosis belt on patients suffering from discopathy. By correlating the various adjustments of a lumbar belt with spinal sagittal profiles, the reliability of posturographic measurements could in future, help clinicians and industrialists by demonstrating the benefit related to the balance between the stress exerted by the lumbar brace and the patient’s specificity.

Conflict of interest statement

None.

Appendix A. A fractional Brownian Motion model (fBm) and centre of pressure (CoP)

If ordinary Brownian motion characterizes random walk processes, the mathematical fBm concept from Mandelbrot and Van Ness (1968) constitutes its generalization. Its main interest is to give evidence of the role of deterministic and stochastic mechanisms involved in a process. In other terms, this model may help evaluate the degree of control of the CoP trajectory. As demonstrated by the following equality $<\Delta x^2> = \Delta t^{2H}$, the analysis principle consists in being interested in the relationship between the mean CoP square displacements $<\Delta x^2>$ and the increasing time intervals $\Delta t$. The graphical representation, which helps us evaluate this type of relationship is called variogram (Fig. 3). Collins and De Luca (1993) were the first to get interested in this tool for CoP trajectory analysis. In the present case, the variograms are made of two successive straight lines (Fig. 3). These authors therefore deduced that two distinct control mechanisms were successively involved during postural maintenance: the first one, of persistent or exploratory origin, acts as an open loop (with no feedback) for the shortest $\Delta t$ whereas the second one, of anti-persistent or corrective origin, acts as a closed loop (by retroaction) during the longest $\Delta t$. The transitional point between these two phases therefore represents the spatio-temporal coordinates $<\Delta x^2>$ and $\Delta t$ of the beginning of the postural correction. The scale or Hurst coefficients (H) represent the main coefficient of each scatterplot half-slope. This H coefficient helps determine the type of processes involved in the control of the considered displacements. Therefore, if its median value (that is 0.5) reveals a totally random walk process, the more distant are the values from this 0.5 threshold value, the better will be the degree of control. These processes are said persistent when $H > 0.5$ (the considered point will tend to move far from its balance point) and antipersis-

Figure 3 Example of a variogram representing the mean centre of pressure trajectory displacements according to the increasing time interval.
tent when $H < 0.5$ (in that case, the most common tendency will be to turn back).

Therefore, when using this model, it is possible to precisely determine the mean time intervals ($\Delta t$) and the more or less hazardous degree of the postural correction ($H_{ll}$).

References


