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Flexibility and Velocity of the Normal and Impaired Lumbar Spine

W.S. Marras, PhD, P.E. Wongsam, MD

Departments of Industrial and Systems Engineering and Physical Medicine, The Ohio State University, Columbus, OH 43210

ABSTRACT. Marras WS, Wongsam PE: Flexibility and velocity of normal and impaired lumbar spine. Arch Phys Med Rehabil 67:213–217, 1986.

• Trunk mobility, as defined by trunk angle, has long been considered an acceptable means to evaluate the degree of impairment in patients with low back pain (LBP). However, biomechanically, there is reason to believe that patients with LBP may exhibit significant sensitivity to trunk velocity of motion as well as angular mobility factors. An experiment was performed to study the trunk action of patients with LBP and of a normal control group. A lumbar monitor was used to monitor both trunk angle range and trunk velocity. The results indicate significant differences between the two groups for both angle and velocity measures. However, the velocity measure revealed more dramatic difference between groups and was the only parameter that was capable of distinguishing between the particular experimental tasks for both LBP and normal groups. Thus, it is suggested that trunk velocity be used as a quantitative measure of low back disorder and that it be used as a means to monitor the rehabilitative progress of patients with LBP.

KEY WORDS: Motion; Spinal injuries; Spine

Disorders of the lumbar spine often are accompanied by changes in the biomechanic behavior of the back. A person with a low back impairment is not able to move and exert force about his body easily. Patients with low back pain (LBP) usually exhibit limitations in terms of the degree of back bend they can achieve and their back motion appears extremely slow and controlled. These limitations may be related to two biomechanic concepts.

First, limited range of bend may be due to the subject's attempt to minimize the static load upon the spine. As one bends forward, the trunk center of gravity moves farther away from the centerline of the body, thus creating an increased moment about the body. This moment must be counterbalanced by the back musculature, and thus, increased loading is experienced within the back.

Second, motion limitations also may be explained in biomechanic terms. According to the Newtonian laws of physics, the force experienced by the back is a function of the product of trunk mass and trunk acceleration. Thus, when the rate of trunk motion decreases in a patient with LBP, there is a reduction in the acceleration component and a resultant reduction in trunk force. Since humans are capable of a broad range of trunk velocities, motion has the potential to greatly increase back loading. In both these situations, it appears that the patient is reducing these activities in a protective fashion in order to guard against excessive loading and the resulting stimulation of nociceptors within the spinal structures.

The measurement of spinal movement often is used as a clinical evaluative tool. Physicians note the range of bend in patients with LBP and use the degree of back bend in diagnosing and assessing the effect of therapy, to check rehabilitative progress, and to gauge the patient's readiness to return to work. This information also may allow for the job requirements to be matched with the worker's capabilities.

Several techniques are used to study the degree of back bend. Reynolds[4] compared three common techniques for measuring back bend. A spondylometer, goniometer, and the skin distraction method were used to measure spine mobility. He concluded that the goniometer, which measures trunk angle, was the only method that was of acceptable accuracy.

Several techniques have been used to study the back mobility of normal subjects.[1,3,5] However, the results of these studies often are not applicable to patients with LBP. Recently, Mayer and co-workers[2] have used an inclinometer to study the spine motion of both normal subjects and those with chronic low back dysfunction. This study demonstrated the significant difference between normal subjects and those who suffer low back disorders. These authors also discussed the value of the inclinometer technique as a tool for monitoring progress in rehabilitation.

These studies have investigated the degree of trunk bend as a measure of spinal dysfunction; however, the velocity of trunk motion may be a more significant factor in the biomechanical action of the low back and may serve as a more reliable measure of low back impairment.

The objective of this study was to determine if a velocity measure can be used as a means to distinguish between normal and impaired backs. Velocity measures also were compared with traditional angle range measures. A lumbar monitor was used to study the characteristic range of bend and velocity in both normal subjects and those with chronic LBP.

METHOD

Subjects. Thirty-four subjects were examined and were categorized into two groups. Subjects had no physical impairments other than LBP. Sixteen men were classified as having chronic LBP. The mean age of this group was 40.5 years (SD,

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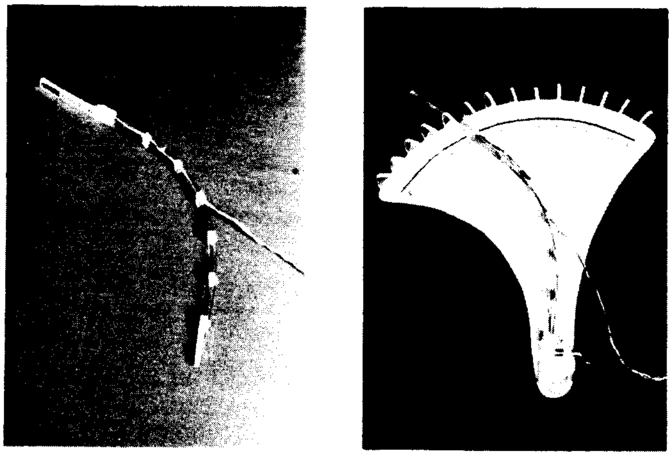

Fig 1—Left, the lumbar motion monitor; right, the monitor with calibration unit.

9.6 years). The control group consisted of 18 men, with a mean age of 32 years (SD, 10.3 years).

Apparatus. The Ady-Hall lumbar monitor[a] (fig 1) was used to measure spine position and velocity. This device consists of a series of stiff wires, which were placed against the lumbar spine. The base of this device was taped to the first sacrum and the upper portion of this device was allowed to move freely within a tube, which was attached to the throracic spine (fig 2). Angular position was measured with a precision potentiometer attached to one of the wires of the lumbar monitor. The potentiometer signal was amplified and recorded. This permanent record of trunk activity allowed the computation of angular velocity as well as trunk angle.

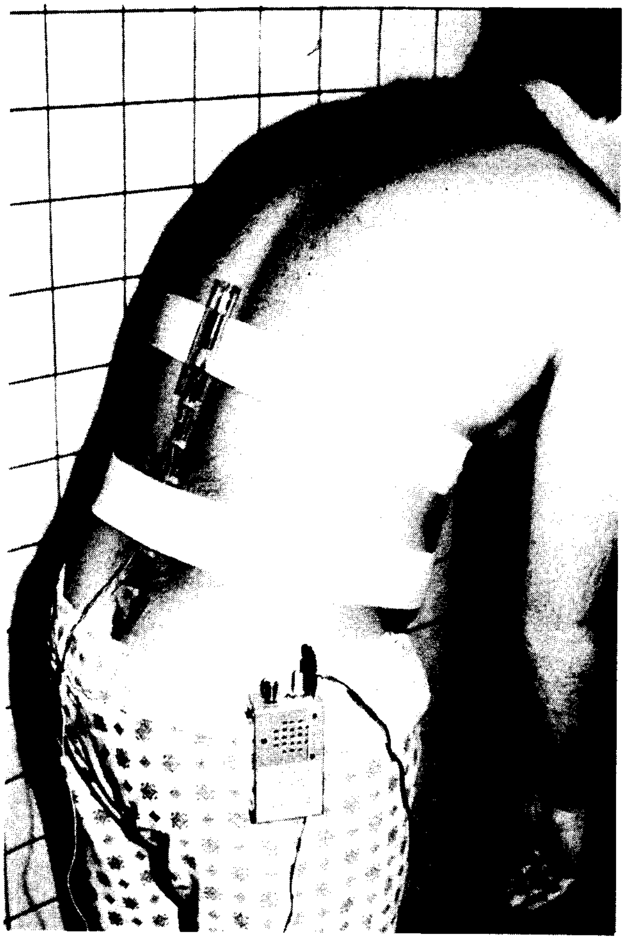

Fig 2—Patient wearing the lumbar monitor.

Procedure. Trunk angle and trunk velocity were recorded under several functional conditions. Subjects were asked to perform several bends in the sagittal plane. During the tasks, subjects were asked to bend to the fullest extent possible under several velocity conditions.

The experimental conditions consisted of the following tasks:

1. Normal standing posture
2. Maximum flexion posture
3. Maximum hyperextension posture
4. Normal velocity flexion with knees straight
5. Normal velocity of reextension (from the flexed position) with knees straight
6. Maximum velocity of flexion with knees straight
7. Maximum velocity of reextension with knees straight
8. Normal velocity flexion with knees bent
9. Normal velocity of reextension with knees bent
10. Maximum velocity flexion with knees bent
11. Maximum velocity of reextension with knees bent
12. Normal velocity hyperextension.
13. Maximum velocity hyperextension

RESULTS

Study results are summarized in fig 3 to 7, which describe the mean and standard deviation of the absolute and relative bend angles and the trunk velocities observed in the experiment. All conditions indicated in the figures represent statistically significant differences in performance between the normal

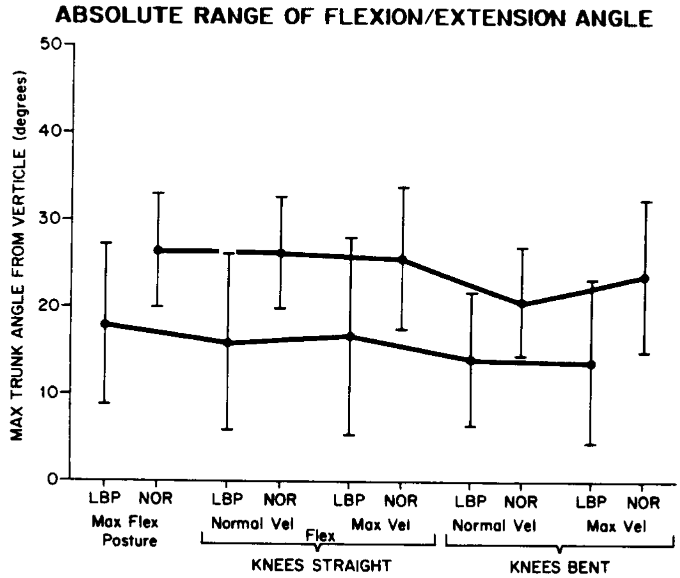

Fig 3—Mean and standard deviation of absolute trunk angle range for all study subjects.

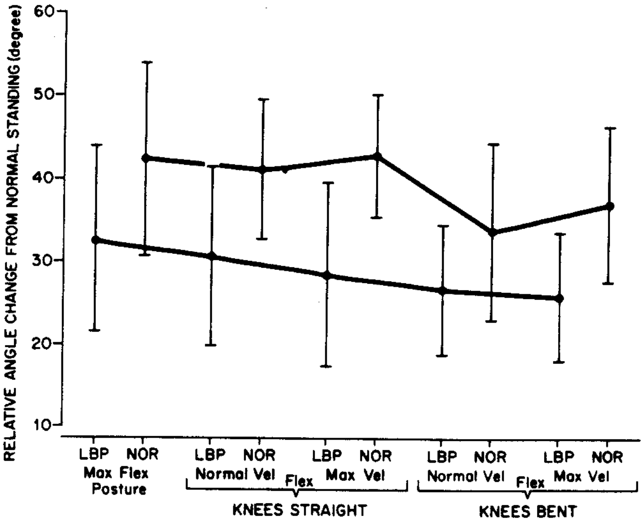

Fig 4—Mean and standard deviation of relative (from upright standing posture) angle range for all study subjects.

and LBP groups. Trunk bend angle range was evaluated both in terms of the absolute degree of bend and relative degree of bend. Absolute degree of bend refers to the angular deviation from vertical, whereas relative degree of bend represents the angular deviation from the normal standing posture. The range of bend was significantly reduced by a relatively constant amount (about 10°) over all conditions in subjects who have suffered low back disorders. The difference between normal and im-

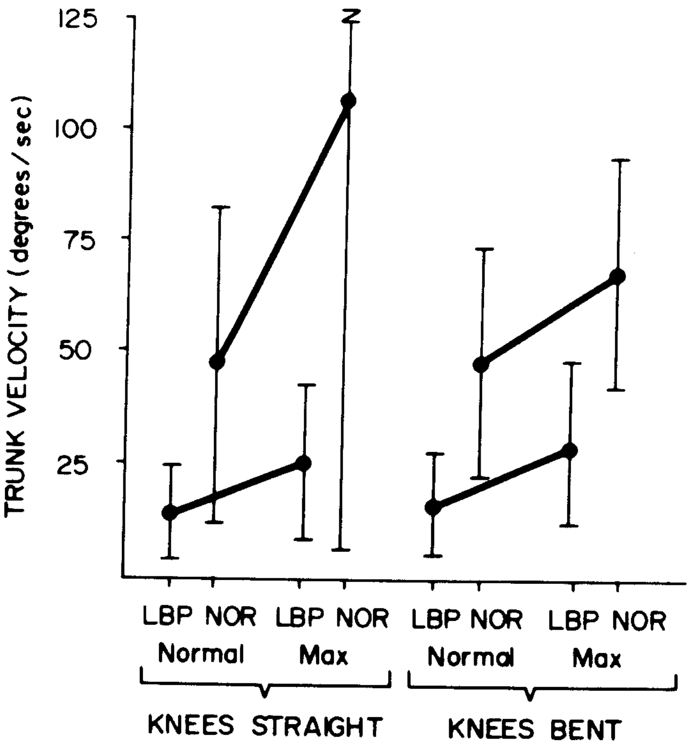

Fig 5—Mean and standard deviation of trunk velocity during flexion for all study subjects.

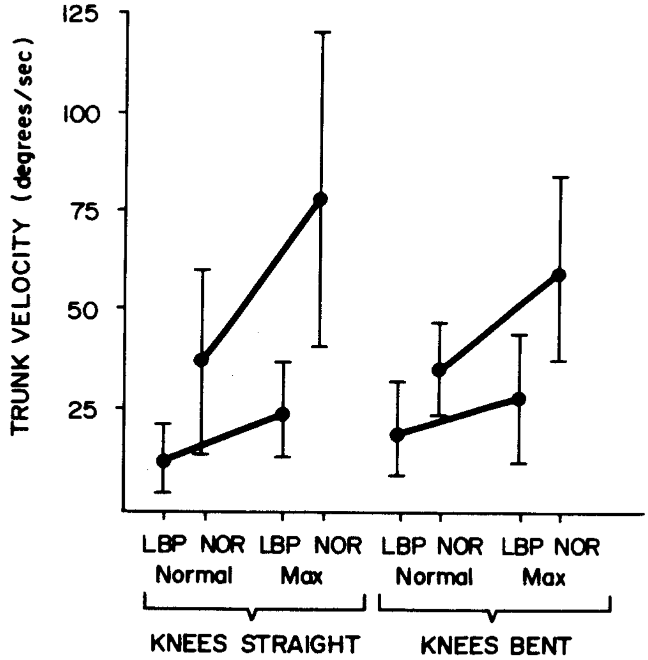

Fig 6—Mean and standard deviation of trunk velocity reextension from flexion for all study subjects.

paired subjects was even more pronounced (15–82°/s) when velocity of motion was considered.

The range of bend and velocity differences were tested under the various experimental conditions by analysis of variance techniques (table). Significant differences (at the 0.05 level) in performance between the experimental conditions were indicated for the normal group when relative angle of bend and velocity were considered. Duncan Multiple Range Tests used to interpret the nature of these differences indicated that there was a change in both relative and absolute angles of back bend for normal subjects when the knee position was changed from a straight to a bent position. More angular range was achieved with the knees straight. No such distinctions were significant within the LBP group.

When the changes in velocity were considered, significant sensitivity within conditions was detected both in the normal and LBP groups during the flexion and reextension tasks. Duncan Multiple Range Tests indicated that within each group distinctive velocity differences were due solely to the differences between the maximum and normal velocity conditions, as opposed to changes in knee positions. Normal vs LBP velocity characteristics are described in fig 5 and 6. Significant changes in velocity patterns were apparent, as the relative change in velocity between maximum and normal conditions during knees straight testing more than doubled for the normal group but less than doubled in the LBP group.

The analysis also indicated that the most dramatic differences were apparent when maximum and normal velocity of hyperextension for normal subjects was compared with that of subjects with LBP. Great increases in velocity were noted for normal subjects, whereas negligible differences occurred in subjects with LBP.

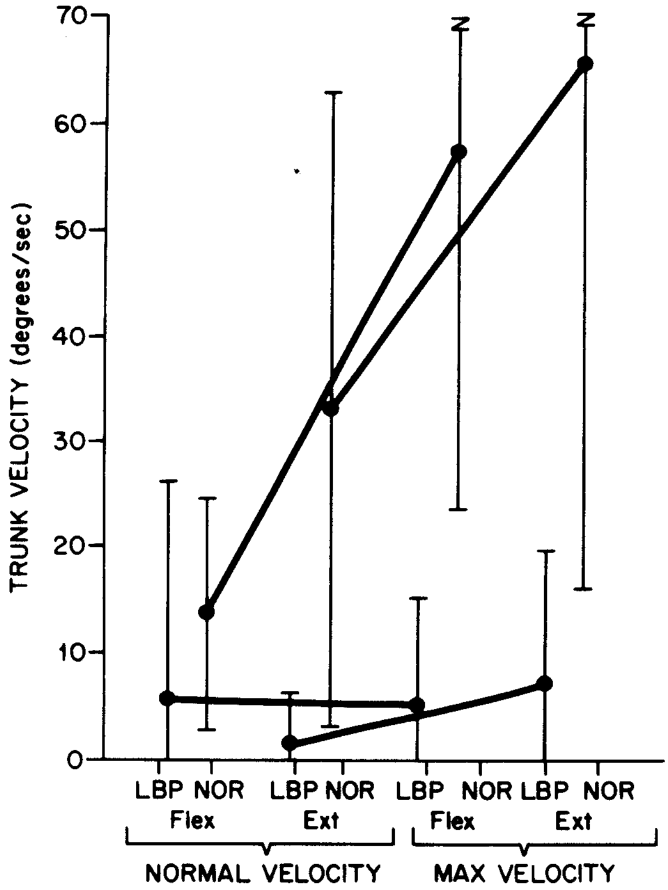

Fig 7—Mean and standard deviation of trunk velocity of hyperextension for all study subjects.

Correlational analysis also was performed for the various experimental conditions. Many significant correlations were observed between the various experimental conditions within each normal and LBP group when the absolute and relative angle of bend was considered. However, when the velocity of motion was considered, significant correlation patterns were observed between experimental conditions within the LBP group but not within the normal group.

Summary of Significance Levels Resulting From Analysis of Variance Test Within Each Group

Performance measure	Normal group	LBP group
Angle		
Absolute bend		
Flexion/reextenstion	0.10	0.67
Hyper flexion/extension	.25	.26
Relative bend		
Flexion	.01*	.36
Reextension	.01*	.06
Velocity		
Flexion	.01*	.03*
Extension	.01*	.01*
Hyperextension	.01*	.70

* Significant at the 0.05 level of acceptance

DISCUSSION

This research has shown that there are significant differences in the flexibility and velocity of normal and injured lumbar spines. This fact in itself is not surprising. However, the present research has quantitatively defined the flexibility and velocity ranges for both normal and injured workers. The reduction of trunk angle of subjects with LBP was about 25% when compared with normal subjects. This reduction in angle was true for relative flexion and extension from the normal standing position. This resulted in a reduction in back flexion angle of approximately 10° for the LBP group. Relative reduction in hyperextension was about 70% for the impaired group when compared with the normal group. It appears that the LBP group was extremely cautious in extending the trunk center of gravity posteriorly during forward flexion when compared with normal subjects. These changes in flexibility due to injury appear to be due to a protective guarding behavior, which occurs after injury. It appears that this guarding may be a means to reduce the moment and, thus, the force about the spine.

More pronounced differences in the velocity of back motion were observed between the normal and LBP groups. Reductions in flexion velocity were at least 50% when the LBP group was compared with the normal group. Significant differences were noted between the velocity capabilities of normal subjects when they flexed at maximum rates with the knees bent and straight. Significantly greater velocity was produced by these subjects with the knees straight. Subjects with LBP, however, demonstrated similar changes in velocities under both conditions.

Hyperextension velocity seemed to show the greatest differences between the two groups tested; this was particularly true under maximum velocity conditions. Injured subjects were able only to produce velocities that were <10% those of their normal counterparts. This may be due to the fact that the back musculature was acting as the agonist muscle group in hyperextension and the difference may be due to muscle sensitivity. Biomechanically, there would be less of a load in hyperextended positions, since the moment about the back would be reduced, as compared with forward flexion, due to the limited range of available hyperextension angle. The extreme control in velocity production also is apparent from correlation pattern evaluation. No such extreme control and reduction in hyperextension velocity was apparent with the control group.

These findings suggest that monitoring the velocity of normal and maximum trunk motion would be a superior method to quantify differences and rehabilitative progress in patients. The changes in velocity due to injury are substantial and subject to less variability, as compared with changes in flexion or hyperextension angle measures. Furthermore, as seen in the table, only velocity measures can differentiate between experimental conditions within the LBP group. Hence, the velocity measure offers more potential for discriminating between trunk performance conditions and increases the quantification potential.

This research also has shown that changes in trunk angle and velocity may be easily and reliably monitored with a lumbar monitor. This device is easy to apply to the subject and can provide an evaluation in less than ten minutes. Additionally, this device also has the advantage of producing a permanent record of the back activity and may minimize the degree of subjectivity.

It is suggested that the flexion and velocity data may be used as a quantitative measure of impairment. Future research could test a larger normal population so that patient data may be compared against this data base and a percentile system that monitors the degree of injury and the rehabilitative progress of patients may be developed. This system also may be integrated into a physical capacities evaluation for injured workers. A monitoring of the required trunk velocity needed to perform a task can serve as a quantitative indicator of when a patient (with a given trunk velocity profile) is able to return to work.

ADDRESS REPRINT REQUESTS TO:
William S. Marras, PhD
Department of Industrial and Systems Engineering
The Ohio State University
1971 Neil Avenue
Columbus, OH 43210

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Supplier

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