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Correlation of Spinal Mobility with the Severity of Chronic Lower Back Pain

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The purpose of this study is to show the correlation between the range of spinal motion and the severity of chronic lower back pain. The subjects of this study were 40 female patients with chronic lower back pain over a 6 months' duration. The range of spinal and hip joint motion was measured with a electrogoniometer, and the severity of back pain was evaluated with the Rolland's score and Pollard's pain disability index. Results were as follows. There was a correlation between the severity of pain and the range of lumbar lateral flexion, rotation, and extension ($p<0.05$). Age, height, weight and body mass index had no correlation with the range of spinal motion. These results suggest that the range of lumbar spinal motion can be used as an objective measure for the evaluation of classifying chronic lower back pain patients and for planning and following their treatment.

Key Words: Chronic low back pain, electrogoniometer, spinal mobility

In acute lower back pain, clinical symptoms can be used as useful indicators for the severity of lower back pain and recovery. But in chronic lower back pain, objective physical signs are often scarce or totally lacking. So the degree of disability and results of treatment are frequently evaluated with subjective pain index scales (Mellin, 1986a, Million *et al.* 1982). But in order to submit basic data as a valuable index when clinicians make a choice of diagnosis and treatment, to provide consistent information for patients, and to offer a convincing diagnostic means, an objective evaluation should be performed. Many methods have been used as an objective evaluation scale in chronic lower back pain such as range of spinal motion, aerobic capacity, and trunk muscle power (Cady *et al.* 1979, Deyo, 1983, 1988, Mcquade, 1988, Hurri *et al.* 1991). Among these, the range of spinal motion has traditionally been accepted as the only objective measure for the exact function of the spine (Waddell *et al.* 1984). However, the technique most generally utilized is invalid and misleading since it does not separate hip from spinal components nor isolate a consistent number of spinal segment(Mayer *et al.* 1985). Also there has been considerable restriction in its wide application because of difficulties in measurement due to complex spinal mobility (Macrae *et al.* 1969). In this study, the correlation of spinal mobility with the severity of back pain is shown with the use of an electrogoniometer that has a 3 dimensional digitizer making it possible to evaluate the pattern of skeletal motion more efficiently, easily, and objectively.

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PATIENTS AND METHODS

The subjects were 40 female patients with lower back pain for more than 6 months, and who visited the Department of Rehabilitation Medicine of Yongdong Severance hospital from October, 1993 to June, 1994. The mean age of the 27 patients in their 40's was 44.4. Among these, the number of patients whose pain lasted from 6 months to 1 year was 21, and those whose pain lasted over 1 year was 6. So the mean duration of back pain in the age 40's was 10.9 months. The mean age of the 13 patients in their 50's was 51.9. Among these, the number of patients whose pain lasted from 6 months to 1 year was 7, and whose pain lasted over 1 year was 6. So the mean duration of back pain in the age 50's was 13.8 months. The mean duration of back pain in all 40 patients was 10.7 months.

They had no bone abnormalities such as compression fracture or congenital deformity which might affect the normal bone skeletal alignment. We used two methods for subjective pain measurement. One is the Roland's scale, the sum of the number for the positive answers to 24 items (Roland *et al.* 1983) (Appendix 1). The other is the pain disability index, the sum of each score for Pollard's 10 questionnaires (Trait *et al.* 1987) (Appendix 2). The range of spinal motion was measured with a FARO electrogoniometer (FARO Metrecom Technologies, Inc. Florida) (Fig. 1). This test was performed 3 times by only one well trained member of our research team, after which the average values were calculated (Fig. 2). If the difference between each time of value was more than 5 degrees or 10 % of full range of motion, the measurement

***Fig. 1.** FARO three dimensional electrogoniometer.*

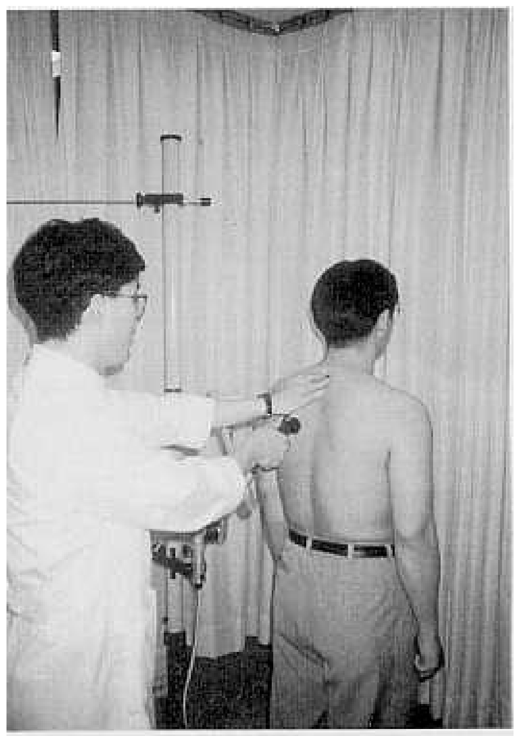

***Fig. 2.** The measuring method of spinal motion by digitizer tip.*

was done 6 times.

The values of thoracic lateral flexion, rotation, and lumbar lateral flexion, rotation, and hip flexion, extension were summated for both sides because the side of which the limitation in joint motion was different according to the side of back pain. If there were any limitation in a joint motion, the summated values for both sides would be smaller than normal. In order to prevent the statistical complexity in relation to the pain side, we summated both values.

Thoracic spine

The examiner digitized (making the computer recognize the three dimensional coordination by putting the electrogoniometer tip on the object) the patient's skin over the spine processes C6, T2, T11, and L2 as the standard points, as the patient was sitting in a chair with a straight back. Then, after the patient flexed her upper trunk fully without tilting the L2 spine, the examiner digitized the same points in a fully flexed posture. The computer in the electrogoniometer calculated the range of thoracic flexion subtracting the values of the three dimensional coordination in a fully flexed position from those with a straight back.

In the sitting position, lateral flexion was measured by digitizing the same points as in the flexion before and after lateral flexion, measuring the range of motion, and then summating the values of range of lateral flexion for both sides.

In the sitting position, rotation was measured by digitizing the spine process C7, posterior acromion process, the spine process T12, and the tip of the right 12th rib as the standard points before and after rotation, and then summating the values of the range of rotation for both sides.

Lumbar spine

Flexion was measured by digitizing the spine processes T11, L2, S1, and S4 as the standard points in standing position before and after flexion, and measuring the range of lumbar flexion.

Extension was measured by digitizing the same points and same position as in the flexion before and after extension. In this case, care should be taken to prevent the pelvis from moving in the anterior-posterior direction.

Lateral flexion was measured by digitizing the same points in the same position as in the flexion before and after lateral flexion, and then summating the values of the range of lateral flexion for both sides. Rotation was measured by digitizing the spine process T12, the tip of the right 12th rib, and the right and left superior posterior iliac spines as the standard points in standing position before and after rotation, and then summating the values of range of rotation for both sides.

Hip joint

Flexion was measured by digitizing the greater trochanter and the lateral margin of the knee joint as the standard points in a supine position with the contralateral hip and knee fully flexed, holding with patient's arms, and then summating the values of range of flexion for both sides.

Extension was measured by digitizing the same points as in flexion in prone position before and after extension, and then summating the values of range of extension for both sides.

The normal values of the range of motion

Table 1. The normal values for range of motion by AMA[1]

Range of motion	Normal values
Thoracic flexion	50
Thoracic lateral flexion[2]	*
Thoracic rotation[2]	60°
Lumbar flexion	60°
Lumbar extension	25°
Lumbar lateral flexion[2]	50°
Lumbar rotation[2]	*
Hip flexion[2]	200°
Hip extension[2]	60°

1: American Medical Association
2: The summated values for bilateral sides
*: Not confirmed

used in the FARO electrogoniometer were defined by the method of the American Medical Association (Table 1).

DATA ANALYSIS

The data was analyzed, using the SPSS statistical program. The statistics employed for analyzing the correlation of the range of spinal and hip joint motion with age, height, weight, and body mass index was linear regression. The correlation of spinal and hip joint range of motion with the Roland's score and the pain disability index was also analyzed by the same method.

RESULT

The mean subject age was 46.9, the mean height was 158.5 cm, and the mean weight was 57.3 kg (Table 2).

There was no significant correlation between age, height, weight, and the body mass index (weight/height$^2 \times 100$), and the spinal range of motion ($p>0.05$) (Table 3).

In the thoracic spine, the mean spinal range of motion was 32.8° in flexion, 71.8° in lateral flexion, and 51.8° in rotation. In the lumbar spine, the mean spinal range of motion was 52.7° in flexion, 17.0° in extension, 36.5° in lateral flexion, and 24.3° in rotation. In the hip joint, the mean range of motion was 254.6° in flexion, and 43.6° in extension (Table 4).

Among the range of hip and spinal motion, the lumbar rotation, extension, and lateral

Table 2. Physical characteristics of cases

	Mean ± SD[1]
Age (years)	46.9 ± 4.3
Height (cm)	158.5 ± 4.5
Weight (kg)	57.3 ± 7.4
BMI[2] (kg/cm^2)	20.9 ± 6.6

1: Standard Deviation
2: Body Mass Index

Table 4. Mean values of range of motion

Range of motion	Mean ± SD1 (degrees)
Thoracic flexion	32.8 ± 8.3
Thoracic lateral flexion*	71.8 ± 17.9
Thoracic rotation*	51.8 ± 11.9
Lumbar flexion	52.7 ± 12.7
Lumbar extension	17.0 ± 9.4
Lumbar lateral flexion*	36.5 ± 12.6
Lumbar rotation*	24.3 ± 8.8
Hip flexion*	254.6 ± 22.1
Hip extension*	43.6 ± 11.7

1: Standard Deviation
*: The summated value for both sides

Table 3. Correlation coefficients between physical characteristics and range of motion

Range of motion	Age(years)	Height(cm)	Weight(kg)	BMI[1](kg/cm^2)
Thoracic flexion	−0.1642	0.0705	−0.2057	−0.0387
Theoraci lateral flexion	0.1954	−0.0994	0.2093	0.2742
Thoracic rotation	−0.1977	0.0236	−0.1015	0.1705
Lumbar flexion	−0.1798	0.2947	0.0917	0.0375
Lumbar extension	−0.0919	−0.0986	0.1632	0.0717
Lumbar lateral flexion	−0.0351	−0.1207	0.0069	0.1471
Lumbar rotation	0.1987	0.1836	0.0125	0.1573
Hip flexion	−0.1023	0.1547	−0.2961	−0.3500
Hip extension	−0.2808	−0.1803	−0.0460	−0.1915

1: Body Mass Index
P-value: 0.05

Table 5. Correlation coefficients: Roland's score and PDI[1] versus range of motion

Range of motion	Roland's score	PDI[1]
Thoracic flexion	−0.0348	0.0102
Thoracic lateral flexion	0.0782	0.0239
Thoracic rotation	−0.2967	−0.3071
Lumbar flexion	−0.2187	−0.0524
Lumbar extension	−0.4375*	−0.3823*
Lumbar lateral flexion	−0.4117*	−0.4568*
Lumbar rotation	−0.4926*	−0.4488*
Hip flexion	−0.1090	−0.0110
Hip extension	−0.2607	−0.3091

1: Pain Disability Index
*<0.05

flexion significantly correlated with the severity of back pain ($p<0.05$) (Table 5).

DISCUSSION

In the evaluation of chronic back pain, subjective feelings for the severity of pain have generally been reported to be more highly correlated with the severity and prognosis of back pain than objective physical findings (Roland *et al.* 1983, Mellin, 1986b, Mellin *et al.* 1990). But because the availability of objective measurements were essential to the diagnosis, the clinician's decision making, as well as reassuring and feeding back information to the patient in a consistent manner, there have been many studies on objective evaluation methods which can accurately reflect the severity of pain (Mayer *et al.* 1985). Many objective measures have been used such as the range of spinal mobility, the strength of back muscles, aerobic capacity, range of hip joint motion, etc(Cady, 1979).

Among these methods, the measure of spinal mobility has been most commonly used for the evaluation of chronic lower back pain. Radiographic methods would be most reliable, but ethical and practical reasons preclude their use for many clinical and scientific purposes, though their advantages in measuring intervertebral movements are obvious. For this reason, methods of noninvasive measurement have been developed, and among these, conventional measurement with a tape has been supplemented by goniometric methods, namely, inclinometer, manual goniometer, and the plurimeter (Mellin, 1986b, Mellin, 1987b). But these methods had some difficulty in discriminating the thoracic, and hip joint mobility from that of the lumbar spine (Mayer *et al.* 1984, Mellin, 1988). In this study, we used a three dimensional electrogoniometer by which we could measure thoracic mobility, lumbar spine and hip joint motion separately right after digitizing the standard points of the musculoskeletal system with the three dimensional digitizer tip. The computer in this electrogoniometer receives the input data of the three dimensional position, locates those points in X, Y and Z axis, and finally analyzes the entire motion of the musculoskeletal system (Smidt *et al.* 1992).

Mellin (1986a) suggested that among various spinal mobilities, lateral flexion and rotation of the spine are highly correlated with the severity and prognosis of lower back pain. He also suggested that hip joint mobility might be related to the severity of lower back pain. Mellin (1987a) reaffirmed the fact that, in chronic lower back pain patients, the pain was more highly correlated with lateral flexion and rotation of thoracolumbar spine than that of the lumbar spine alone. In this study, lateral flexion, and rotation as well as extension of the lumbar spine were most highly correlated with the severity of chronic lower back pain. The difference of this study from Mellin's was that all of the subjects were females in their 40s to 50s, and we used a three dimensional electrogoniometer which was convenient for the operator to use and which gave less discomfort to the patient to take posture. Mellin's group measured the spinal mobility with a tape method, and their subjects were males and females with various age levels. In spite of these differences, we have attained the similar result that lateral flexion and rotation of the lumbar spine were most highly correlated with the severity of chronic lower back pain. Some difference between our result and Mellin's might be expected to be caused by the variability of sex and age.

Mellin (1987b) said that the reason why the lateral flexion and rotation of lumbar spine was most highly correlated with the severity of back pain was that the lateral flexion and rotation of lumbar spine were activities rarely used in the individual's daily living, so the muscles involved in the lateral flexion and rotation might become shortened more severely than the other muscles.

In one of Mellin's papers (1986a), lateral flexion and rotation of the lumbar spine were most highly correlated with the severity of chronic lower back pain in men, but not rotation in women. Perhaps the circumference of the abdomen itself might affect the degree of rotation regardless of the severity of pain, especially in middle aged women. As Mellin already mentioned, body mass index (weight/hight$^2\times 100$) was inversely correlated with the degree of spinal mobility in the normal control group. So, those who have a high body mass index, especially middle aged women, might have some limitation in range of spinal rotation regardless of the severity of pain.

In our study, correlation of body mass index with spinal mobility was not seen. The lumbar rotation as well as lateral flexion was also highly correlated with back pain in women probably due to lower body mass index of Korean middle aged women in comparison with those in the western world.

Mayer and his colleagues (1985) asserted that the measurement of spinal mobility was a very objective method for evaluating the severity and prognosis of chronic lower back pain, and thus helping to treat chronic lower back pain patients. But he found that there was great difficulty in obtaining precise measurements of spinal mobility because of the complexity of the spine and its many joints. So he concluded there would be restriction in the wide application of this method for evaluating chronic lower back pain paitents. In this study, the three dimensional goniometer eliminated this limitation for effective measurement of spinal mobility.

In conclusion, as a result of measuring the range of spinal and hip joint motion with a FARO electrogoniometer, there was a correlation between the severity of pain and the range of lumbar lateral flexion, rotation, and extension. The range of lumbar spinal motion was a useful objective measure for the evaluation of chronic lower back pain patients and for the follow up of treatment results. As mentioned above, we also were able to reduce difficulty in obtaining precise measurement of each spinal segment separately by using the three dimensional electrogoniometer, and could confirm that the lumbar spinal mobility was highly correlated with the severity of chronic lower back pain and could be a useful measure for the objective evaluation of degree, prognosis, and follow up study of back pain.

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DISABILITY QUESTIONNAIRE(with Instructions)

1. I stay at home most of the time because of my back.
2. I change position frequently to try and get my back comfortable.
3. I walk more slowly than usual becuase of my back.
4. Because of my back I am not doing any of the jobs that I usually do around the house.
5. Because of my back, I use a handrail to get up-stairs.
6. Because of my back, I lie down to rest more often.
7. Because of my back, I have to hold on to something to get out of an easy chair.
8. Because of my back, I try to get other people to do things for me.
9. I get dressed more slowly than usual because of my back.
10. I only stand up for short periods of time because of my back.
11. Because of my back, I try not to bend or kneel down.
12. I find it difficult to get out of a chair because of my back.
13. My back is painful almost all the time.
14. I find it difficult to turn over in bed because of my back.
15. My appetite is not very good because of my back pain.
16. I have trouble putting on my socks(or stockings) because of the pain in my back.
17. I only walk short distances because of my back pain.
18. I sleep less well because of my back.
19. Because of my back pain, I get dressed with help from someone else.
20. I sit down for most of the day because of my back.
21. I avoid heavy jobs around the house because of my back.
22. Because of my back pain, I am more irritable and bad tempered with people than usual.
23. Because of my back, I go upstairs more slowly than usual.
24. I stay in bed most of the time because of my back.

***Appendix 1.** Roland's score.*

PAIN DISABILITY INDEX

1. *Family Home Responsibilities.* This category refers to activities related to the home or family. It includes chores and duties performed around the house (eg, yard work) and errands or favors for other family members(eg. driving the children to school)

0	1	2	3	4	5	6	7	8	9	10
no disability										total disability

2. *Recreation.* This category includes hobbies, sports, and other similar leisure time activities.

0	1	2	3	4	5	6	7	8	9	10
no disability										total disability

3. *Social Activity.* This category refers to activities which involve participation with friends and acquaintances other than family members. It includes parties, theater, concerts. dining out, and other social functions.

0	1	2	3	4	5	6	7	8	9	10
no disability										total disability

4. *Occupation.* This category raters to activities that are a part of or dinectly related to one's job. This includes nonpaying jobs as well, such as that of a housewife or volunteer worker.

0	1	2	3	4	5	6	7	8	9	10
no disability										total disability

5. *Sexual Behavior.* This category refers to the frequency and quality of one's sex life.

0	1	2	3	4	5	6	7	8	9	10
no disability										total disability

6. *Self Care.* This category includes activities which involve personal maintenace and independent daily living(eg, taking a shower, driving, getting dressed, etc).

0	1	2	3	4	5	6	7	8	9	10
no disability										total disability

7. *Life-Support Activity.* This category refers to basic life supporting behaviors such as cating, sleeping, and breathing.

0	1	2	3	4	5	6	7	8	9	10
no disability										total disability

Appendix 2. *Pain disability index.*