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# Comparison of two stretching protocols on lumbar spine extension

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**Abstract**. *Purpose*: To compare range of motion (ROM) outcomes of repeated extension versus static stretching of the lumbar spine in healthy adults.
*Methods*: 101 subjects volunteered and were randomly assigned to 1of 3 groups: repeated extension (Group A, $n = 33$), static stretching (Group B, $n = 36$), or control (Group C, $n = 32$). Double inclinometers were used to measure lumbar extension ROM (prone). Measurements were taken at baseline, 4 weeks, and 8 weeks. MANOVA assessed equivalence of the 3 groups for age and initial ROM; chi-square testing assessed gender differences. ROM data were assessed using General Linear Mixed Model Analysis. Alpha was set at 0.05.
*Results*: Both methods of stretching increased lumbar extension ROM at 4 and 8 weeks. The repeated stretching group increased ROM more than the static group. Group A differences were significant comparing 8 to 4 weeks and to baseline. Group B differences were also significant comparing 8 to 4 weeks and to baseline. At 8 weeks, only group A was significantly different than the control group.
*Conclusion*: Repeated and static stretching improved lumbar extension ROM when compared to no stretching. However, repeated extension when compared to static stretching showed greater gains in lumbar extension ROM after 8 weeks of stretching.

Keywords: Range of motion, flexibility, low back

## 1. Introduction

Decreased spinal range of motion (ROM) is commonly associated with low back complications, and functional ROM must be restored to allow for the return to previous activity levels [4,8]. Several methods can be incorporated to facilitate increased ROM, including static stretching, repeated/cyclic stretching, passive stretching, and proprioceptive neuromuscular facilitation; however, controversy exists over which of these methods is most efficacious in increasing ROM [15].

According to Kisner and Colby [7], stretching is a general term used to describe any therapeutic maneuver designed to lengthen shortened tissue structures and thereby increase ROM. Static stretching is one method used to increase flexibility of soft tissues. A static stretch is performed by stretching shortened structures to end range and holding this position for several seconds [7]. Bandy and Irion [2] studied the effects of static stretching in 15, 30, and 60-second intervals. They determined that 30-second and 60-second stretches increased range of motion more than a 15-second stretch, but there was no difference between the effectiveness of 30-second and 60-second stretches.

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Repeated/cyclic stretching is another method used to increase ROM by elongating shortened tissues. According to McKenzie's [13] classification, Dysfunction Syndrome is the condition in which adaptive shortening of soft tissues and resultant loss of mobility cause pain by stretching of shortened tissues which block full end range movement. Dysfunction can be the result of poor postural habits, previous trauma, or inflammatory or degenerative processes. These events cause contraction, scarring, adherence and adaptive shortening or imperfect repair and pain is felt when the abnormal tissue is stretched [13]. Treatment of the Dysfunction Syndrome consists of postural correction along with repeated end range movements to remodel shortened structures. According to McKenzie [13], this intermittent stress provides an adequate stretching effect and that this protocol is most effective in the treatment of extension dysfunction. McKenzie [12] also reports that patients in the dysfunction syndrome category are likely to be over 30 years of age having had more time to suffer the above described effects which would limit spinal ROM.

Although the effects of static stretching and cyclic stretching are widely reported, the studies are mostly related to extremity joints [7]. Further investigations are necessary to determine which method is more effective and what is the effect in increasing lumbar extension ROM. The purpose of this study was to compare the effects of repeated extension versus static stretching on lumbar extension ROM. It was expected that both stretching groups would increase ROM. The researchers' hypothesis was that subjects in the static stretching group would exhibit a significantly greater increase in lumbar extension ROM than subjects in the repeated extension group based on extremity studies [6].

## 2. Methods

### *2.1. Subjects*

Prior to the study, the university's Institutional Review Board gave approval to the researchers to perform this study. One hundred and one volunteers from the community began this 8-week study; however, subject dropout decreased the number to 61 who completed the protocol. Subjects ranged from 26 to 62 years of age. Each subject was informed of the risks of the study prior to signing a consent form. The subjects were randomly assigned to 3 groups by drawing numbers from a hat before the initial measurements were taken. Random assignment was chosen so that the probability of 1 group being biased toward a certain attribute, such as age or gender, would be decreased [14]. Thirty-three subjects were assigned to group A (the repeated extension group). Thirty-six subjects were assigned to group B (the static stretching group). Thirty-two subjects were assigned to group C (the control group). Exclusion criteria included the following: low back pain within the previous 6 weeks that limited work or recreational activities; any surgery of the spine, trunk, or upper extremity surgery within the previous 6 months; symptomatic scoliosis; spinal fusion; neurological symptoms (including numbness or tingling in the low back or lower extremities); connective tissue disease (i.e., rheumatoid arthritis, scleroderma); pregnancy; or any other medical condition which would hinder ability to participate in the study.

### *2.2. Apparatus*

For this study, fluid-filled inclinometers (Biokinetics, Inc.; Leeds, UK) were used to measure lumbar ROM with the double inclinometer method. The American Medical Association's *Guides to the Evaluation of Permanent Impairment* [1] recommends the use of hand-held inclinometers for the measurement of sagittal and coronal plane mobility of the lumbar spine. Saur and colleagues [**?**] concluded that the double inclinometer technique is a reliable and valid method for measurement of lumbar ROM that makes it possible to measure and differentiate movements of the hip from those of the lumbar spine. Mayer and colleagues [10] also found that the double inclinometer technique had appropriate intratester reliability.

### *2.3. Procedures*

Measurements were taken at initial evaluation, at the end of 4 weeks, and at the end of 8 weeks. Subjects were required to wear clothing that allowed access to necessary bony landmarks, including the spinous processes of the T12 and S1 vertebrae. The subjects were positioned in prone on a standard plinth, and the T12 and S1 spinous processes were palpated and marked for reference. The subjects were instructed to perform a prone press-up by placing the hands (palms down) at shoulder level. They were then instructed to exhale while pressing the top half of the body up by straightening the arms. The body inferior to the chest was allowed to sag with gravity. The participants were instructed to allow the back to sag into maximum extension and then to lower the top half of the body back to the plinth. This action was performed 5 times to allow the participants to become accustomed to the motion. Incorporating the method described by Saur and colleagues [?], prior to the sixth press-up one inclinometer was placed over the T12 spinous process, and the second inclinometer was placed over the S1 spinous process. Each inclinometer was zeroed with the subject in the prone lying position. The subjects then performed a press-up for measurement. As the subjects held a maximally extended position, the readings on the 2 inclinometers were noted, and the difference between the 2 readings was recorded as the lumbar extension ROM. For consistency, one researcher carried out all the measurements on each subject.

Group A subjects were instructed to perform 12 exercise repetitions, sustaining the last 2 repetitions for 5 seconds each. Participants were asked to perform one exercise session every 2 hours (a total of 8 exercise sessions per day), beginning after waking in the morning. The subjects were encouraged to perform the exercises in a prone position. However, if a flat, clean surface was not readily available; subjects were allowed to perform exercises in a standing position. To perform the exercise in standing position, the subject stood with the feet shoulder width apart with hands in the small of the back. The subject leaned backwards as far as possible using the hands as a fulcrum keeping the knees fully extended. The subject then returned to erect standing position. The last 2 repetitions were again sustained for 5 seconds.

Group B subjects were instructed to perform the same prone press-up procedure while holding the maximally extended position for 30 seconds. The members of this group were instructed to perform the procedure in the prone position only. Group B subjects performed 4 repetitions in the morning and 4 repetitions in the evening.

Members of groups A and B were instructed to follow the stretching regime 7 days a week for 8 weeks. Each participant was given written instructions for the proper stretching regimen and a daily stretching chart to record compliance. Daily stretching periods were equalized between groups A and B. Group A members were instructed to perform a repeated extension exercise session 8 times per day. For each session, the participant was asked to perform 12 repetitions of the exercise. For the first 10 repetitions, the participant stretched to the end range position and immediately returned to neutral. For the last 2 repetitions of the session, the participant held the end range position for 5 seconds before returning to neutral. Performing this exercise as instructed resulted in 4 minutes of stretching per day. To equalize stretching times between the exercise groups, members of group B were asked to perform 4 repetitions of the static stretch twice per day (once in the morning/once in the evening). These participants held the end range position for 30 seconds for each repetition before returning to neutral. This regimen also totaled 4 minutes of stretching per day. Both groups were instructed to perform their first stretching session in the morning and finish the last stretching session in the evening.

Researchers made 2 attempts to contact each subject in Groups A and B during the course of the study to encourage exercise compliance. The phone calls were made at 2 weeks and at 6 weeks.

Group C was designated the control group and had measurements taken at the initial evaluation, at the end of 4 weeks, and at the end of the 8 weeks. Members of this group were instructed not to begin a new exercise program and were encouraged to maintain normal daily activity levels during the 8-week study period.

### *2.4. Data analysis*

The equivalence of the 3 treatment groups was assessed using the Multivariate Analysis of Variance for 2 variables: (a) age and (b) initial lumbar ROM. This analysis was performed to assess whether any significant differences existed among the 3 groups in terms of the 2 variables. Means and standard deviations of the 2 variables were calculated for each of the 3 treatment groups.

A chi-square test was performed to check for gender differences among the 3 groups. A 3-group by 2-gender table was used to discover any significant difference in the distribution of gender for the 3 groups.

Finally, range of motion data was assessed using the General Linear Mixed Model Analysis of Variance with the logarithm transformation to satisfy the normality assumption. The first-order antedependence covariance matrix for the observations for each subject was the best-fitted model with maximum Akaike Information Criterion. The Akaike Information Criterion was used to choose among competing models for the General Linear Mixed Model. Actual range of motion means were reported, but tests using Tukey's post hoc procedure were conducted on the transformed variable. Significance for all statistical tests was set at the 0.05 alpha level.

Table 1
Means and standard deviations for age and initial, 4 weeks, and 8 weeks range of motion (ROM)

| Group | n | M | SD | 95% | C.I. |
|---|---|---|---|---|---|
| Age | | | | | |
| Repeated (A) | 20 | 43.6 | 9.3 | 39.3–47.7 | |
| Static (B) | 22 | 44.5 | 9.5 | 40.4–48.5 | |
| Control (C) | 19 | 43.8 | 10.6 | 39.0–48.7 | |
| Total | 61 | 44.0 | 9.6 | 41.5–46.4 | |
| Initial ROM (degrees) | | | | | |
| Repeated (A) | 20 | 21.0 | 7.9 | 17.5–24.5 | |
| Static (B) | 22 | 20.3 | 10.5 | 15.8–24.7 | |
| Control (C) | 19 | 20.0 | 8.3 | 16.8–23.8 | |
| Total | 61 | 20.4 | 8.9 | 18.2–22.7 | |
| 4 Weeks ROM (degrees) | | | | | |
| Repeated (A) | 20 | 23.4 | 9.2 | 19.3–27.5 | |
| Static (B) | 22 | 21.7 | 9.9 | 17.4–25.9 | |
| Control (C) | 19 | 20.1 | 8.7 | 16.1–24.1 | |
| Total | 61 | 21.7 | 9.3 | 19.3–24.1 | |
| 8 Weeks ROM (degrees) | | | | | |
| Repeated (A) | 20 | 28.5 | 10.7 | 23.7–33.2 | |
| Static (B) | 22 | 26.5 | 10.8 | 21.9–31.1 | |
| Control (C) | 19 | 18.9 | 8.1 | 15.1–22.6 | |
| Total | 61 | 24.6 | 10.6 | 22.0–27.5 | |

## 3. Results

One hundred one subjects were initially (Group $A = 33$, Group $B = 36$, Group $C = 32$) recruited for the study. Sixty-two subjects remained at 4 weeks (Group $A = 21$, Group $B = 22$, Group $C = 19$), and 61 remained at 8 weeks (Group $A = 20$, Group $B = 22$, Group $C = 19$). The following data analyses pertain to the remaining 61 subjects who completed the full study.

No significant differences were found in the means of the 2 variables for the 3 treatment groups at baseline: (a) age and (b) initial lumbar ROM (Wilk's $\lambda = 0.996$; $F = 0.05$; $df = 4, 114$; $P = 0.995$). Mean values for age and initial ROM, 4 weeks, and 8 weeks are reported in Table 1.

Gender distribution among the 3 treatment groups was assessed using the chi-square test. No significant association was noted in the distribution for gender for the 3 groups ($\chi^2 = 3.10$; $df = 2$; $P = 0.212$). Gender breakdown was as follows: Group A (males = 7, females = 13), Group B (males = 11, females = 11), Group C (males = 12, females = 7).

The test of the fixed effects of the General Linear Mixed Model Analysis of Variance indicated that the group * time interaction was found to be significant $F = 3.42$; $df = 4, 116$; $P = 0.011$). Mean ROM values for each treatment group at each measurement are given in Table 1. The Tukey's post hoc procedure was used to determine where the significance occurred in the group*time interaction (Fig. 1).

Mean compliance rates for each stretching group were also monitored. The compliance rates were calculated for the first 4 weeks (Group A, 69.4%; Group B, 70.3%), second 4 weeks (Group A, 63.1%; Group B, 65.7%), and the overall 8 weeks (Group A, 66.1%; Group B, 68.2%). The mean compliance rates for the 2 groups were not compared with a statistical test because the compliance rates were based on different exercises. However, there was no more than a 2.6% difference in compliance between groups A and B at the end of the first 4 weeks, and 8 weeks. For group A, the mean percentage of time in which the repeated exercise was performed was 19.2% of the time in the prone position ($1^{st}$ 4 weeks = 17.4%; $2^{nd}$ 4 weeks = 21.5%) and 80.8% percent of the time in the standing position. These figures were not compared with a statistical test due to the overall low percentage of these exercises done in a prone position ($1^{st}$ 4 weeks = 82.6%; $2^{nd}$ 4 weeks = 78.5%).

In summary the two stretching groups both showed significant differences in mean ROM when comparing initial and 4 week measurements to final measurements. Improvement was noted between initial measurement and 8 weeks and between 4 weeks and 8 weeks. No significant difference was noted in either stretching group between initial measurement and 4 weeks. Group C showed no significant change in mean ROM across time. No significant difference was found in mean ROM among all 3 groups at 4 weeks. At 8 weeks, however, group A showed a significant difference from group C, but not from group B. Group B showed no significant difference from group C.

## 4. Discussion

Based on the results of this study, the original hypothesis was not supported which stated that subjects in the static stretching group (Group B) would exhibit a greater increase in lumbar extension range of motion (ROM) compared to subjects in the repeated stretching group (Group A). As noted above, the two stretching groups both showed significant differences in mean ROM when comparing initial and 4 week measurements to final measurements. The control group (Group C) showed no significant change in mean ROM across time. No significant difference was found in mean ROM among all 3 groups at 4 weeks. At 8 weeks, however, the repeated stretching group showed a significant difference from the controls, but not from the static

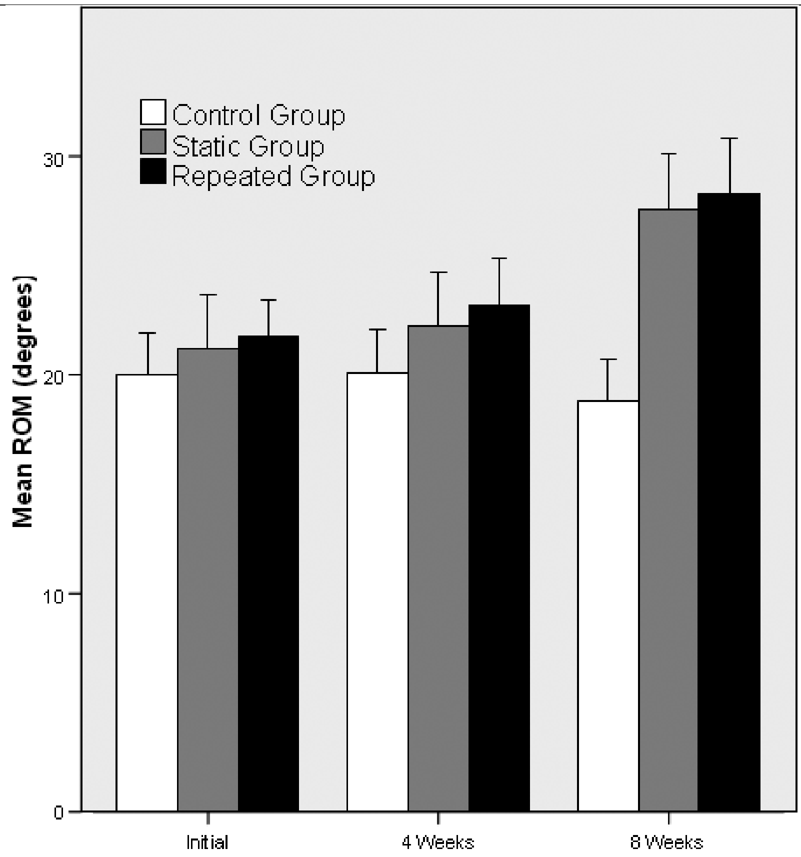


Fig. 1. Mean ROM change at initial, 4 weeks, and 8 weeks for control, static and repeated stretching groups. Values are means ± SE.

stretching group. The static stretching group showed no significant difference from the control group.

Group A subjects performed the majority of their exercises in standing. Standing lumbar extension accounted for 80.8% of the exercises performed by group A over the course of the study versus 19.2% in prone. This suggests that results for group A are better represented by standing lumbar extension compared to prone lumbar extension; however, no studies were found that suggest standing lumbar extension increased lumbar extension ROM more than prone extension. McKenzie [13] advocates the use of both techniques and reports that both exercises are effective for treating low back Dysfunction Syndrome.

Taylor and Twomey [?] reported that the decline in lumbar ROM with age is secondary to the replacement of elastin with collagen and a decrease in elasticity secondary to an increase in cross-linkage of collagen fibers within the soft tissue structures of the spinal column. No significant ($P < 0.05$) differences were found among the 3 treatment groups with respect to mean age and mean initial measurement of lumbar extension ROM in the present study; therefore, these variables had no significant effect on the results.

Cummings and Tillman [5] reported that remodeling dense connective tissue could change the strength and shape of muscle components. This occurred at various rates in different tissues. They reported that short-term stretching with a strain of 4 to 6 percent could be used to permanently increase tissue length by denaturing collagen and fracturing some of the collagen bundles. However, the authors made no mention of the stretching time required to obtain the permanent changes.

Bandy and colleagues [3] found that both dynamic ROM and static stretching increased the flexibility of hamstring muscles. Static stretching for 30 seconds, however, was found to be more effective than dynamic ROM (a series of 6, 5-second stretches adding up to 30 seconds of stretching). Contrary to this study, the present study showed no significant difference between the repeated stretching group and the static stretching group; however, a significant difference ($P < 0.05$) was found between the repeated stretching group and the control group. No such significant difference was found between the static stretching group and the control group.

Smith and Mell [?] found a significant ($P < 0.025$) difference between males who performed repeated lumbar stretching, using the McKenzie technique, and those who did no exercise. They determined that subjects who performed the exercise increased their lumbar extension ROM, while those who did not perform the exercise decreased their lumbar extension ROM.

Madding and colleagues [9] reported that a short-term stretch was as effective as a long-term stretch for increasing hip abduction ROM. This study was limited to 1 session of stretching and Bandy and Irion [2] noted that no long-term effect was known using these methods of stretching. Looking for a long-term effect, Bandy and Irion [2] had subjects perform stretching exercises throughout a 6-week period. We were also interested in a long-term effect and opted to have subjects perform stretching exercises for 8 weeks.

Potential problems with the present study have mainly to do with measurement. Improper reading or placement of the inclinometers could be one source of error. Mayer and colleagues [11] described common errors identified by test administrators, including the ability to identify bony landmarks, movement of the skin mark as the subject extended, and the tendency of the device to shake over bony landmarks.

With the results of the present study showing a significant ROM improvement in extension with 8 weeks of stretching with repeated, frequent exercise, a study using subjects with specific ROM deficits would be in order. We recommend that future studies be performed to control more variables associated with the study. One variable that could be controlled is body weight. Obesity could have been a factor in finding bony landmarks, which might have led to incorrect measurements for those particular subjects. We also suggest that future studies compare different exercise positions to test their effectiveness on increasing ROM. We allowed our repeated stretching group to use both prone and standing positions. The effectiveness of prone position exercises could be compared to those done in standing. We also recommend that various age groups (20 s, 30 s, 40 s, and 50 s) be compared to assess whether subjects from different age ranges would exhibit different increases in lumbar extension range of motion following the same stretching protocol. Other methods could be studied to see what approach would increase compliance rates. This would allow for a better assessment of the effects of various stretching techniques over time.

## 5. Conclusion

Both methods of stretching significantly increased lumbar extension ROM in asymptomatic subjects at 4 weeks and 8 weeks. The repeated stretching group increased ROM more than the static group over the duration of the study, but it was not a significant difference. Only the repeated stretching group showed a significant improvement over the control group at 8 weeks.

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