Flexibility Retention 3 Weeks After a 5-Day Training Regime

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Objective: To determine the retention of flexibility 25 days after 5 days of three 30-second stretches.

Design: A 2 × 4 repeated-measures factorial. Treatment and time were independent variables. The dependent variable was flexibility as measured by a sit-and-reach box.

Measurements: 33 college students were tested before and after stretching for 5 consecutive days and without stretching on days 8 and 30. Control subjects were prone for 15 minutes; stretch subjects received 15 min of diathermy or sham diathermy and then performed three 30-second standing right-hamstring stretches.

Results: Flexibility was greater on days 5, 8, and 30 than day 1, but days 5, 8, and 30 were not different from each other.

Conclusion: Gains in flexibility are retained for at least 3 weeks after a stretching program. It also appears that 2 sets of 3 repetitions of a sit-and-reach test is sufficient stimulus to induce long-term flexibility gains.

Key Words: sit-and-reach, stretching

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Flexibility development through stretching has been researched extensively. Factors such as type,[1-4] duration,[5-8] frequency,[6-8] and the effect of modalities[9] on stretching have all been investigated. In each of these, the effects of the protocol have been monitored through the completion of the regime. We found 1 study of stretch retention, and it involved same-day or acute carryover affects.[10] Apparently, no one has reported on long-term (chronic) retention of flexibility gains after cessation of training. The question that prompted this investigation was, Do gains achieved during a flexibility-training program remain after an extended period of no stretching?

Methods

This report is based on an extension of an 8-day study by Draper et al (submitted for publication) on the combined effects of diathermy and

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stretching on sit-and-reach performance. Subjects were divided into 3 groups: a control group and 2 treatment groups (stretch with and without diathermy) that trained for 5 days. Each group was pretested and posttested daily for 5 days and tested again on day 8. Both treatment groups stretched 3 times for 30 seconds on days 1–5. The idea for a follow-up study came during the data analysis of the first study.

A 2 × 4 factorial design with repeated measures (time) was used for this study. The dependent variable was sit-and-reach test scores, measured in centimeters. The 2 independent variables were treatment (control and stretch) and time (day). Subjects were called 2 1/2 weeks after the previous study and asked to return for a follow-up measurement. Because there was no difference between treatment groups in the original study, we combined the 2 stretch groups for this study. Data from the first, fifth, and eighth day of the original study were analyzed with new data from day 30.

Subjects

Thirty-three (M = 11, F = 22, age = 20.6 ± 1.8 years, ht = 169.5 ± 8.5 cm, wt = 66.7 ± 14.9 kg) of the 36 original subjects returned for this study. Three of the original subjects who were not part of this study included 2 who had changed their exercise habits after the original study and 1 who was unavailable. The 33 subjects reported that they had not stretched regularly or changed their exercise habits since day 8 of the original study. The original volunteers were healthy college students taking classes in the Department of Physical Education at Brigham Young University. Prospective subjects were excluded from the original study if (1) their straight-leg hip-flexion range of motion was greater than 100°; (2) they had a history of either hamstring or low back injury; (3) they had metal pins, plates, or screws in the right femur; (4) they were or could possibly be pregnant; or (5) during the study, they reported any discomfort that the researchers deemed to be more than the normal sensation of stretched tissue. The study was approved by the university's Institutional Review Board. All participants gave informed consent.

Instruments

A standard plastic goniometer (Fred Sammons Inc, Bissell Healthcare Corp, Brookfield, Ill), marked in 1° increments, was used during subject selection to screen subjects' straight-leg hip-flexion range of motion. Sit-and-reach range of motion was tested with a Figure Finder Flex-Tester sit-and-reach box (Novel Products Inc, Rockton, Ill) modified with a 2-in-diameter tube at its base.

Procedures

During testing, subjects sat barefoot with their legs under the ledge of the sit-and-reach box, the right (treatment) leg extended, heel against the tube, and the left leg slightly bent (because it was not treated or stretched). In an effort to reduce triceps surae muscle tightness, the ankle was plantar flexed over the 2-in-diameter tube so that the toes touched the sit-and-reach box (Figure 1). Subjects then overlapped their hands and slowly stretched forward as far as the right leg would allow. The distance that subjects' fingers reached along the sit-and-reach box was recorded; the best of 3 trials was used for statistical analysis.

After pretesting, subjects lay prone on a treatment table with their feet off the end of the table for 15 minutes. During the 15-minute rest, subjects in the stretch group had either short-wave diathermy or sham diathermy applied, but this had no effect as reported elsewhere.[11] Subjects were then either posttested (control group) or stretched and then posttested.

The stretch-group subjects performed three 30-second stretches. They stood on their left foot (toe turned out laterally approximately 25° from midline) in front of a table 2 1/2 ft high (Figure 2). The distance between the left foot and the table was measured with a tape measure fixed to the floor to ensure that all of the stretches were performed identically. The subject placed the right leg on the table with the heel fixed 3 in behind a 4-in ledge, so that the foot would remain in a relaxed but plantar-flexed position (to eliminate any effect of triceps surae muscle tightness). To stretch, the subject leaned forward over the right leg and extended the fingers as far as possible along a tape measure that was fixed to the table. The subject was instructed to continue the stretch for the allotted time, working the fingers farther along the tape measure while exhaling. The distance attained during each 30-second stretch was recorded. During each stretch, subjects were prompted to reach as far as they could with each exhalation.

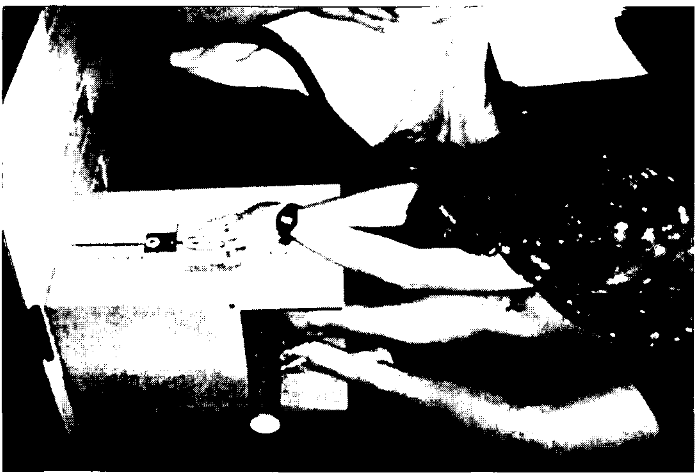

Figure 1 Figure Finder Flex-Tester sit-and-reach box (Novel Products Inc, Rockton, Ill) modified with a 2-in-diameter tube at its base.

Figure 2 Positioning for standing static hamstring stretch.

Subjects rested for 15 seconds between stretches by lowering the right leg and standing erect. After the third 30-second stretch, the sit-and-reach test was again administered.

Statistical Analysis

The data were summarized by group and time. A 2 × 4 analysis of variance with repeated measures was computed on the raw data to identify differences in range of motion between group and time. Newman–Keuls multiple-comparison tests were computed to identify differences between times. Percent changes were computed by subtracting sit-and-reach-box values for day 1 from days 5, 8, and 30 and then dividing by the day-1 value.

Results

Both groups increased in range of motion, but there was no difference between groups (Table 1; $F_{1,93} = 2.08$, $P = .15$, power = .30). Range of motion

Table 1 Unilateral Sit-and-Reach Measurements Before Treatment (cm, change from day 1 and % change from day 1, mean ± SD)

	Control (n = 10)			Stretch Only (n = 23)			Total (N = 33)		
Day*	cm	Change	% Change	cm	Change	% Change	cm	Change	% Change
1	29.3 ± 8.2			29.4 ± 8.2			29.4 ± 8.1		
5	32.1 ± 6.9	2.8 ± 3.6	12.4 ± 16.1	34.8 ± 7.2	5.4 ± 4.6	22.4 ± 22.5	34.0 ± 7.1	4.6 ± 4.5	19.3 ± 21.1
8	33.3 ± 7.0	4.0 ± 4.2	16.7 ± 18.3	36.7 ± 7.2	7.4 ± 4.6	29.9 ± 23.6	35.7 ± 7.2	6.3 ± 4.7	25.9 ± 22.7
30	31.9 ± 6.6	2.6 ± 3.1	11.5 ± 13.4	35.5 ± 7.9	6.1 ± 4.4	24.2 ± 21.0	34.4 ± 7.6	5.1 ± 4.3	20.3 ± 19.7

*Day 1 < days 5, 8, and 30; no difference between groups.

increased with time ($F_{2,93} = 4.2, P = .02$, power = 0.72): 19% ± 21% from day 1 to day 5 (Newman–Keuls < .05), 26% ± 23% from day 1 to day 8 (Newman–Keuls < .05), and 20% ± 20% from day 1 to day 30 (Newman–Keuls < .05). There was no difference between days 5, 8, and 30 (Newman–Keuls > .05).

Discussion

Because this apparently is the first report of the lasting effects of flexibility, there is little with which to compare our results. In a study just completed in our laboratory, gains in triceps surae flexibility (4.5%) after 14 treatments over 3 weeks were retained for 21 days (unpublished data).

Although there was no difference between the control group and the stretching groups, there were large variations in change values. With a larger sample size there might have been significant differences between groups. The purpose of this report, however, is the retention of flexibility, not how the flexibility was developed. Our testing protocol (2 sets of three 5-second repetitions—30 seconds total—of the sit-and-reach test daily for 5 days) was sufficient to increase flexibility. The control group stretched 30 seconds per day during testing, and the stretching group stretched for 120 seconds per day (testing plus three 30-second repetitions of stretching).

Our subjects' flexibility changes were similar to those in other studies.[2,5,12] Sullivan et al[12] reported an 18% increase in range of motion in subjects who performed a 30-second static standing hamstring stretch once a day, 4 times a week, for 2 weeks. Bandy et al[5] reported a 27% increase in hip range of motion as measured by an active knee-extension test after 6 weeks of standing hamstring stretching ,5 days a week, once a day for either 30 or 60 seconds. Perhaps 1 week of stretching is as effective as 6 weeks of stretching.

Halbertsma et al[7,13,14] suggested that the increase in range of motion after stretching is not the result of lengthening the muscle or reducing collagen stiffness of the hamstrings but rather that it results from an increase in stretch tolerance, which they define as pain tolerance.[13] We did not measure muscle length or stiffness, so we cannot suggest the cause of our subjects' flexibility increases. It does seem, however, that the increase in flexibility in our control subjects resulting from short-duration sit-and-reach-box tests might be a result of an increase in subjects' stretch tolerance.

We caution readers about interpreting the 2% increase from day 5 to day 8 as resulting from the weekend rest. The day-5 measurement was prestretching, so the difference between days 5 and 8 was the result of 1 day of stretching and 2 days of rest. Future research on the carryover effects of stretching must include a measurement on the day after the last day of stretching. This will enable accurate evaluation of the acute effect of the last day of stretching and the chronic or carryover effects of the entire stretching protocol.

These data prompt many interesting questions: How long do the gains last? What is the relationship between the length of the training program and the length of retention? Do the characteristics of the training program (ie, duration, sets, reps, days, type, and intensity of stretch) influence the duration of retention? What is the nature of the retention (ie, do the gains increase, decrease, or plateau)?

Conclusion

Flexibility gains resulting from 5 days of training (three 30-second static stretches per day) combined with 6 days of sit-and-reach testing (six 3-second repetitions per day) were retained for 3 weeks after cessation of training and testing. It appears that 2 sets of 3 repetitions of a sit-and-reach test are sufficient stimulus to induce long-term flexibility gains.

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