Effect of 3 Different Active Stretch Durations on Hip Flexion Range of Motion

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Abstract

Ayala, F and Sainz de Baranda, P. Effect of 3 different active stretch durations on hip flexion range of motion. *J Strength Cond Res* 24(2): 430–436, 2010—The purpose of this study was to evaluate the efficacy of 3 different durations of active stretch (12 × 15, 6 × 30, and 4 × 45 seconds) in a hamstring stretching exercise program on lower extremity range of motion (ROM) in young adults. A total of 150 subjects (age, 21.3 ± 2.5 years; height, 173. 33 ± 8.35 cm; weight, 70.42 ± 10.80 kg) completed this study. Subjects were randomly assigned to 1 of 4 groups (3 treatment groups and 1 control group). The 3 treatment groups participated in an active stretching program 3 times per week for a 12-week period, holding each stretch exercise for a duration of 15, 30, or 45 seconds. The total daily dose of the stretches was 180 seconds for each group. The control group did not stretch. Passive hip flexion ROM was determined through the bilateral straight leg raise test before, during (at 4 and 8 weeks), and after the program using an inclinometer. Statistical analysis ($p < 0.05$) revealed a significant interaction of length of stretching program and improvement in ROM. Post hoc analysis showed that all 3 treatment groups increased hip flexion ROM from their initial values; however, the control group did not. No significant differences were found between the 3 treatment groups. This study indicates that 12 × 15-, 6 × 30-, and 4 × 45-second single durations of active stretching were equally effective at increasing hamstring length when performed 3 days per week for 12 weeks in this population.

Key Words stretching, ROM, stretch daily dose, flexibility, hamstring muscles

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Introduction

Low flexibility has been found to predispose a person to several musculoskeletal overuse injuries and significantly affect a person's level of function and performance (2,21,35,38,39). Short hamstring muscles are associated with low back pain (5,7,25) and lower extremity injuries (10,34). Consequently, several studies have suggested that it is necessary to perform systematic stretching exercises to improve hamstring muscle flexibility (11,20,25,33).

Several researchers have analyzed which flexibility training parameters are the most appropriate to improve hamstring muscle length and consequently may obtain greater values of hip flexion range of motion (ROM): technique (11,18,28, 29,37), duration (3,16,23), number of repetitions (4,9,31), length of program (8), frequency (33), and stretch position (12).

According to Nelson and Bandy (27), stretching techniques can be classified into 2 large groups: dynamic or ballistic methods and static methods. Within static methods, there are active and passive types, differentiating self-stretching technique and proprioceptive neuromuscular facilitation (PNF) within the passive types.

The effectiveness of the passive self-stretch, PNF, and ballistic stretching techniques has been proven by several studies (11,13,18,28,37). Few studies have analyzed the effectiveness of the active stretching technique (36). Only Sullivan et al. (36), Robert and Wilson (30), Ford et al. (16), and Davis et al. (11) have investigated the effects of an active stretching program on hip ROM in healthy young adults.

In this study, the active stretching program has been chosen because there is some evidence that active technique may improve lower extremities flexibility. Moreover, Kolber and Zepeda (20) suggest that the active stretching technique allows greater quality and effectiveness of the stretching protocol being designed because this technique produces a greater increase in the distance between hamstring muscle origin and insertion than other techniques.

Generally, increases in flexibility have been associated with duration of application of the tensile force to lengthen muscle and connective tissue. Several authors have suggested effective durations ranging from 5 to 60 seconds (3,9,14,16,23, 30,31), although there is still no clear evidence for the optimal duration for each stretching technique. Several studies have investigated the effect of different stretching durations on passive hamstring stretching programs (3,6,9,29,31), but only Ford et al. (16) and Robert and Wilson (30) have investigated the effect of different stretching durations (30, 60, 90, and 120 seconds) on active hamstring stretching programs.

Nevertheless, no studies have been found about the effect of short stretching durations (15, 30, and 45 seconds) of long-term active hamstring stretching programs (12 weeks) with a repeated measures design. Furthermore, no studies have been found that focus on the gains in flexibility made by subjects who possess moderate to high flexibility levels. Therefore, the aim of the present study was to investigate whether active stretching improves hip flexion ROM and to examine the effects of 15, 30, and 45 seconds of active stretches during a 12-week stretching program in subjects with moderate to high flexibility levels.

Methods

Experimental Approach to the Problem

A repeated measures design was used to determine the effectiveness of 3 common stretching durations during a 12-week training program. The design allowed for the investigation of possible interaction effects for the different durations of stretching. The dependent variable was passive range of motion (PROM) as measured by the straight leg raise (SLR) test, and the independent variable was active stretching duration with 4 levels (0, 15, 30, and 45 seconds).

The hypotheses were that active stretching improves hip flexion ROM after following a regular stretching program and that the single stretch duration is less important than the total daily stretch duration. To determine the validity of these hypotheses, this study designed 3 different stretching programs, which had the same total daily duration (180 seconds) but different single stretch duration (15, 30, or 45 seconds).

The SLR test was performed before, during, and after the program on the stretching groups and the control group to examine the effects of active stretching of hip extensor muscles.

Subjects

A total of 150, healthy, young adult, university students (106 men and 44 women; mean $\pm$ *SD*: age, 21.3 $\pm$ 2.5 years; height, 173. 33 $\pm$ 8.35 cm; weight, 70.42 $\pm$ 10.80 kg) took part in the present study. All subjects were free of delayed onset muscle soreness and injury in their lower extremities. They were recreationally active subjects but were not involved in regular training. Recreationally active was defined as sporadic participation in sporting activities. In other words, each person had to engage in sporting activities no more than 60 minutes and no more than 3 times per week (19). Subjects were advised not to change their exercise routine, and those who missed more than 3 stretching sessions were eliminated from the study. Subjects with short hamstrings ($<65°$) based on a passive straight leg raise (PSLR) test described previously (17) were excluded (to maintain a homogeneous design).

All subjects were informed of the methods to be used and the purpose and risks of the present study, and informed consent was obtained from all subjects. The protocol of the present study was approved by the ethics committee of the Catholic University of San Antonio (Murcia, Spain). The subjects were randomly assigned to control and experimental groups. The control group was composed of 22 men and 7 women. Experimental group A (22 men and 13 women) performed twelve 15-second stretches (12 $\times$ 15 seconds), experimental group B (35 men and 12 women) performed six 30-second stretches (6 $\times$ 30 seconds), and experimental group C (27 men and 12 women) performed four 45-second stretches (4 $\times$ 45 seconds).

Stretching Treatments

Subjects taking part in the 3 stretching treatments performed the active stretching exercises 3 days per week, always on nonconsecutive days, during 12 weeks. Subjects performed 4 different stretching exercises in each training session. Two of the exercises were performed while standing (bilateral A and unilateral A), and 2 were performed while sitting (bilateral B and unilateral B) (Figure 1).

The 3 active stretching programs had different single stretch durations (15, 30, or 45 seconds) and exercise repetitions (12, 6, or 4 repetitions). Stretching group A performed 3 alternating repetitions of each exercise, and all repetitions were held for 15 seconds. Stretching group B performed 1 repetition of unilateral stretching exercises and 2 repetitions of bilateral stretching exercises, holding for 30 seconds in each exercise. Stretching group C performed 1 repetition of each stretching exercise, and all repetitions were held for 45 seconds. Between each stretching repetition, the subjects' hip extensors were returned to a natural position for a 20-second rest period (41). The order of application of the stretching exercises was random for each stretching session.

Stretching instructions were based on work initially described by Sullivan et al. (36) and later applied by Kolber and Zepeda (20), Winter et al. (40), and Ford et al. (16). From a biomechanical perspective, the following stretch technique was used: hands were kept on hips; head was held in a neutral position and looking straight ahead; the leg to be stretched was kept fully extended; the cervical, thoracic, and lumbar spines were extended; and the scapulae were retracted. In each stretching exercise, subjects tilted the pelvis forward to create a lordosis in the lumbar spine (Figure 1).

After initial instructions and demonstrations, each subject was issued a home exercise sheet that included a schematic representation of the stretching mode and written instructions on the technique. To supervise their stretching training program, each subject had to complete a personalized calendar of their stretching activity and was contacted every week by one of the investigators. The control group did not receive a training program. To supervise this group, the participants were contacted every week and were asked to complete a questionnaire at the end of the study. The main

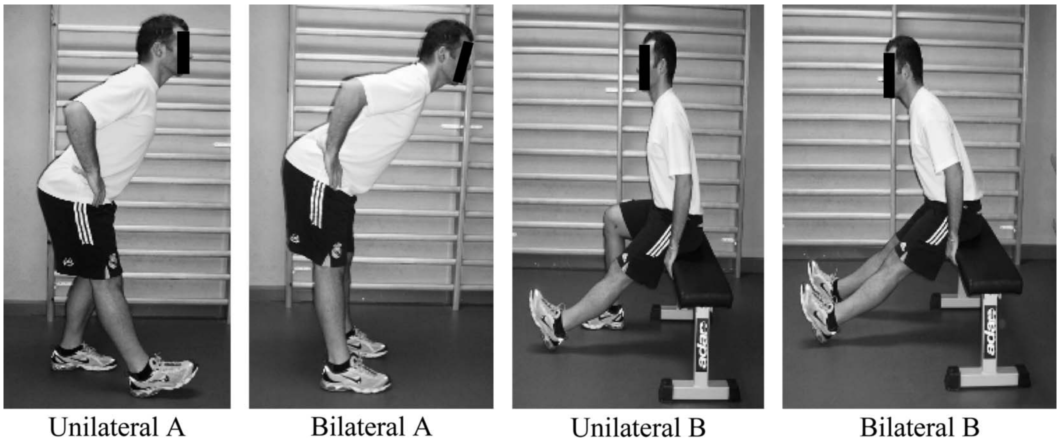

Figure 1. Positions for stretching exercises.

goal of this questionnaire was to make to sure that the subjects of the control group did not undertake additional stretching exercises during the intervention period (24).

Performance Testing

Hip flexion ROM was measured at the beginning of the study, at 4 and 8 weeks after the stretching programs began, and immediately after the stretching programs finished. Two days of rest were provided before the posttest (26). Measurements were performed throughout the study by the same examiner. The examiner was blinded to group assignment throughout the investigation. To eliminate the effect of an acute stretching bout on performance, the intermediate testing session (4 and 8 weeks) and last testing session started 72 hours after the last stretching session had been completed.

Subjects were examined in their underclothing and without shoes. Moreover, no warm-up or stretching exercises were performed by the subjects before test measurements (16), and room temperature was set at 25°C. The hip flexion passive range of motion (PROM) was assessed by using the bilateral SLR (15,33).

Straight Leg Raise Test. The subject was in the supine position with legs straight and ankle of the tested leg in 90° of dorsiflexion. A lower back protection support (Lumbosant) was used to keep normal lordotic curve (32,33). A trained examiner kept the contralateral leg straight to avoid external rotation and fixed the pelvis to avoid the posterior pelvic tilt (initial position). The test administrator placed the inclinometer (ISOMED, Portland, Oregon) over the distal tibia, and the free hand was placed over the opposite knee to keep it straight (22,26). The subject's leg was lifted passively by the tester into hip flexion. Both legs were tested. The endpoint for straight leg raising was determined by 1 or both of 2 criteria: (a) the examiner's perception of firm resistance with or without (b) palpable onset of pelvic rotation. The score criterion of hip flexion PROM was the maximum angle read from the inclinometer at the point of maximum hip flexion (Figure 2).

Before data collection, the reliability coefficient was evaluated on 12 healthy subjects using a test-retest design. Range of motion was measured twice with a week interval. An interclass correlation coefficient was calculated from the results of subsequent measurements. Results of pre- and post-measurements showed a high reliability coefficient ($r = 0.96$).

Statistical Analyses

Mean and standard deviations were calculated for all measurements of hip flexion PROM of each group. In

Figure 2. PSLR test. PSLR = passive straight leg raise.

TABLE. Mean (*SD*) values for degrees of PROM hip flexion.†‡

PROM (SLR)	Control group ($n = 29$)	Group A (12 × 15 s), ($n = 35$)	Group B (6 × 30 s) ($n = 47$)	Group C (4 × 45 s) ($n = 39$)
Pretest	87.32 (±11.84)	87.88 (±11.89)	88.60 (±14.21)	87.76 (±9.81)
4-week test	88.78 (±12.32)	97.72 (±13.46)*	96.34 (±15.85)*	97.03 (±11.76)*
8-week test	90.07 (±11.34)	106.23 (±11.40)*	103.71 (±16.38)*	100.52 (±11.60)*
Posttest	89.47 (±13.00)	107.73 (±12.24)	109.00 (±17.62)*	109.20 (±12.37)*
X4–X1	+2.15	+19.85	+20.4	+21.44

*$p < 0.05$.
†Control group did not stretch, group A stretched for 15 seconds (12 × 15), group B stretched for 30 seconds (6 × 30), group C stretched for 45 seconds (4 × 45); X4–X1: differences between the posttest and pretest averages.
‡PROM = passive range of motion; SLR = straight leg raise.

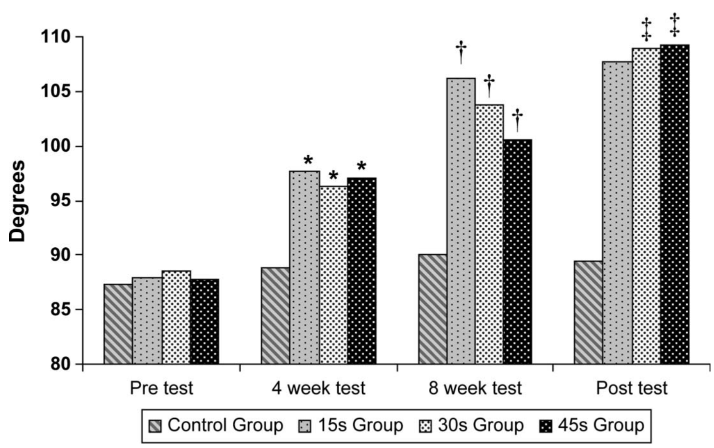

Figure 3. Individual treatment mean differences in PSLR over time. *PSLR angle at 4 weeks significantly greater than baseline PSLR angle. †PSLR angle at 8 weeks significantly greater than PSLR angle at 4 weeks. ‡PSLR angle at 12 weeks significantly greater than PSLR at 8 weeks. PSLR = passive straight leg raise.

addition, for each group, the mean difference between pretest and posttest measurements was calculated.

A 1-way analysis of variance (ANOVA) was used to determine whether there was equal variance between groups in the pretest measurements. The effects of stretching intervention on PROM across time were tested by a 4 × 4 (time × group) ANOVA to determine whether groups differed in mean change in PROM. Tukey's post hoc comparison was used to identify significant pairwise group differences. Intragroup flexibility progression was calculated using a Student's *t*-test for paired data. All data were analyzed using SPSS 13.0 for Windows. Statistical significance was set at $p \leq 0.05$.

RESULTS

It is demonstrated in the Table that at pretest, there was no difference in hip flexion PROM among the 3 stretching groups and the control group. After 4 weeks of stretching, significant increases in ROM over pretest occurred in the 3 stretching groups. After 8 weeks of stretching, all 3 stretching groups (12 × 15, 6 × 30, and 4 × 45 seconds) produced statistically significant improvements in hip flexion PROM from their own pretest and 4-week test. Likewise, in the posttest, all groups improved but the improvements found in stretching group A (12 × 15) were not significant.

The results show no significant differences in the joint ROM between right and left sides for the 4 groups. Thus, only the results of the right side will be presented.

The mean for the pretest and posttest measurements and the change in scores for each group are presented in the Table. The results demonstrated a significant difference for the main effect of time between pretest and posttest PROM measurements ($p < 0.05$). Tukey's post hoc analysis demonstrated a significant difference ($p < 0.05$) between the control group and each of the stretching groups in mean PROM change during the study. No differences were found among the 3 stretching groups in the posttest results. However, significant differences were found only between group A and the other groups in the test taken after 8 weeks.

DISCUSSION

The present study's findings do not suggest significant differences in the initial ROM between right and left sides of the participants in the 4 groups. Furthermore, no significant differences were observed between right and left sides. The findings of the present study are in accordance with some similar studies (3,11,16,30,31).

Additionally, the results of this investigation suggest that a 12-week active hamstring stretching program executed 3 days per week was effective in increasing hip flexion PROM. The findings of the present study are in total accordance with those of Ford et al. (16) and Roberts (PE) and Wilson (30), who suggested that active stretching techniques improve flexibility when stretching exercises are performed systematically. In this regard, similar results were found in elementary school children (33) and subjects with low back pain (40).

Perhaps, active stretching is the most appropriate stretching technique to improve hamstring muscle because it increases the flexibility of the tight muscles while concomitantly improving function of the antagonistic muscles (30). Also, the anterior pelvic tilt prevents unnecessary lumbar flexion, facilitates the natural lumbar lordosis, and consequently protects the intervertebral discs from undue stress (20).

These results showed that active stretching improved hip flexion PROM at 4, 8, and 12 weeks after beginning a stretching program (Figure 3). This investigation contradicts the findings of Davis et al. (11) and Chan et al. (8) about length of the stretching program.

Davis et al. (11) found that active stretching did not result in a significant increase in hip ROM over a control after performing a 4-week stretching program 3 days per week. Perhaps, a possible explanation is the fact that this investigation used only 30 seconds of total daily stretch duration and their participants had poor initial flexibility scores, whereas this study used 180 seconds of total daily stretch duration and subjects with moderate flexibility scores.

Moreover, Chan et al. (8) found that passive stretching programs lasting 4 and 8 weeks were equally effective in increasing hamstring flexibility in young adults. The findings in the present study contrast with the findings by Chan et al. (8) because these results show that 8 weeks after beginning the stretches, the increase in hip flexion PROM is significantly greater than after 4 weeks of the stretching program.

The ACSM (1) suggests that 3 days per week of flexibility training is adequate for a healthy exercise program. Therefore, subjects in this study performed these stretching protocols 3 days per week.

Bandy and Irion (3) compared the effectiveness of 3 single durations (15, 30, and 60 seconds) of passive hamstring stretching 5 days per week for 6 weeks. They found that 30- and 60-second stretches were superior to the 15-second stretch, and there was no statistically significant difference between the 30- and 60-second single stretch.

Similar results were found by Ford et al. (16), who showed that an intervention of 30, 60, 90, or 120 seconds of active stretching once daily for 5 weeks was effective in increasing the flexibility of the hamstring muscles, and there was no significant difference among the single stretch durations.

Provance et al. (29) found that 30 seconds of passive stretching was an effective duration for increasing the flexibility of the hamstring muscles in subjects with limited hamstring flexibility when stretching was performed 5 days per week during 6 weeks.

When the scores of the 3 treatment groups were compared in the present study, there were no significant differences in improvements made in hip flexion PROM in the posttest. No relationship was revealed between single stretch duration and improvement in PROM when the total daily dose of the stretch remained the same for each stretch group (180 seconds). Therefore, the present study suggests that no particular single duration was better with regard to its quantitative effect on chronic gains in ROM.

The results of this study partly corroborate the conclusions of Robert and Wilson (30), Rubley et al. (31), and Cipriani et al. (9) in that a single short stretch duration was as effective as a single longer stretch duration of up to 120 seconds with the same daily dose of the stretch. In addition, the results of our investigation corroborate the notion by both Robert and Wilson (30) and Cipriani et al. (9) that the total time spent stretching on a given day may be more important than the actual duration of a single stretch repetition. The overall time duration appears to be a key factor influencing stretching effectiveness.

Robert and Wilson (30) reported that a 5-week active stretching program of 9 × 5 seconds or 3 × 15 seconds did not result in differences when ROM was assessed passively (mean changes of 6.0° and 6.1° in hip flexion, respectively), but significant differences were apparent for active ROM, with the 15-second group showing significantly greater improvements ($p < 0.05$) than the 5-second group (mean changes of 8.5° vs. 4.8° in hip flexion).

Rubley et al. (31) found no statistically significant difference between 6 × 5-second passive stretches and 1 × 30-second passive stretches in improving hamstring length. Cipriani et al. (9) compared 6 × 10-second active stretches with 2 × 30-second active stretches during a 6-week program. They found no statistical difference between the 2 stretching protocols.

In this study, all experimental groups obtained similar differences between the posttest and pretest average; however, experimental group A obtained this score before the other groups. Therefore, experimental group A (12 × 15 seconds) was equally effective when compared with the other groups in improving hip flexion PROM but it was more efficient.

This study suggests that the 3 different stretching protocols may be useful for the clinician, coach, and recreationally active subjects when they are developing a healthy exercise program because it improves hip flexion PROM, it is safe for the participants, and it presents an easy and comfortable administration, although experimental group A is the most efficient. In addition, as suggested by Cipriani et al. (9), perhaps for individuals who tolerate long-duration type stretching, the protocol of 45 seconds or longer may be best. However, for individuals who do not tolerate the sensation of stretching, a shorter duration (i.e., 15 seconds), more frequent approach may be best suited for them.

One of the limitations of this study is that only the PSLR was used to test hip flexion PROM. Moreover, this research has only investigated the chronic effect of active stretching on hip flexion PROM in recreationally active subjects. Therefore, the results of this investigation should not be generalized for the acute effect of active stretching on performance and to persons outside the sample population. Therefore, more studies are necessary to analyze the effect of active stretching programs in subjects with lumbar pain, older subjects, and athletes. In addition, further research is needed to investigate the effect of active stretching on both muscular strength and ROM.

Practical Applications

The findings in this study revealed that 12 weeks of an active stretching program with a total daily dose of 180 seconds of the stretches on 3 days per week is effective in improving hip flexion PROM in young adults. Active stretching durations of 12×15, 6×30, and 4×45 seconds were equally effective at increasing hip flexion PROM, but the 12×15-second active stretch was the most efficient. Strength and conditioning specialists are encouraged to use this stretching program with their athletes and clients because it is easy to administer, it is comfortably performed, it may improve intermuscular balance (hamstring-quadriceps), and it is safe for the spine. In addition, for subjects who do not tolerate the sensation of stretching, 12×15 seconds of active stretches may be best, although this supposition is purely theoretical. The effect of acute stretching before intensive physical activities should be considered by strength and conditioning specialists before using this active stretching program as part of a pre-exercise warm-up routine.

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