# ANALYSIS OF THE INFLUENCE OF STATIC STRETCHING AND ECCENTRIC TRAINING ON FLEXIBILITY OF HAMSTRING MUSCLES

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Previous studies have investigated the efficacy of stretching exercises and eccentric training in hamstring flexibility. The objective of this study was to comparatively investigate the efficacy of eccentric training and static stretching in flexibility gain, using a different eccentric training protocol. This study included 13 individuals having on average 23.15±1.72 years of age. The subjects were trained 3 times a week for 6 weeks and a pre- post- comparative analysis was conducted. It was observed that both static stretching and eccentric training resulted in the same non-significant gains in hamstring muscle flexibility. Probably eccentric training is a better training strategy for being able not only to increasing flexibility but for being able to increase strength and protect against muscle damage.

**KEY WORDS:** hamstring muscles, flexibility, eccentric training, static stretching, range of motion

## INTRODUCTION:

Static stretching (SS) of hamstring muscles has been shown to be efficient for gain in flexibility, but not to prevent injuries associated to muscle shortening. There is a consensus in the literature about the hypotheses that eccentric training (ET) can be an efficient way to increase flexibility, according to Nelson and Bandy (2004); strength, according to Decoster *et al.* (2005) and prevent muscle strain, according to Brockett *et al.* (2001) and Franklin (2003). Nelson and Bandy (2004) have conducted a comparative study of these training practices. Their results showed that both SS and ET were efficient for gain in flexibility when compared to the control group, but did not, however, exhibit differences between them. The propose of this study was to assess the effectiveness of the eccentric training in comparison to static stretching in increasing hamstring flexibility.

## METHOD:

**Data Collection:** This study included 13 individuals having, on average: 23.15±1.72 years of age, 60.8±7.26 kg of body mass, 1.65±0.08 m of height, and 22.38±2.13 kg/m$^2$ of body mass index. Both lower extremities were utilized, totaling 26 legs randomly allocated into one of three groups (ten in the ET group – ETG –, six in the SS group – SSG –, and ten in the control group – CG). Legs of a same individual were allowed to be assigned to different groups in order to minimize the influences of inter-subject characteristics in the results.
The proposal of this study was approved by the Ethics Committee of Centro Universitário Newton Paiva, and volunteers signed an agreement to participate. The examiners were previously trained on the procedures, and a pilot study was then conducted to verify the reliability of the flexibility measurements (Intraclass Correlation Coefficient =0.98).
Hamstring flexibility was measured in the three groups, by the popliteus angle (maximum amplitude reached at the passive extension of knee with hip flexed at 90º) up to the point at which the researcher felt a firm resistance to the movement. Hamstring flexibility was measured using a goniometer *(Baseline Evaluation Instruments, Baseline Group©, Chattanooga, TN)* with one-degree increments.

For ET, a low pulley was utilized (*Eagle Fitness Sports®*). The volunteer lied supine, with legs hanging down from the high end of the patella. One of the researchers pulled the bar up to the 90º position of the knee flexion, limited by a metal shield (hamstring concentric); the volunteer performed the extension movement alone (hamstring eccentric), with the adequate load for his/her training, according to the consensus of the *American College of Sports Medicine* (2002). The protocol utilized was: three sets of ten repetitions at 70% of a maximum repetition, with one-minute intervals between series.
For SS, a movement was done towards hip flexion with extended knee at a supine position up to the maximal level of discomfort of the volunteer. The protocol was: one series of 30 seconds, adequate for ROM gain, as recommended by Decoster *et al.* (2005)
In the two experimental groups, the training sessions were carried out three times a week, during six weeks. The CG performed no training. The three groups were reevaluated for flexibility at the end of the study.

**Data Analysis:** The means of the popliteus angle measurements between the three groups were compared using Analysis of Variance (ANOVA) for repeated measurements with an intragroup factor (repeated measurements) and other factor between groups. The level of significance was at $\alpha=0.05$.

**RESULTS:**

Table 1 shows the descriptive statistics results of the total sample in relation to the flexibility variable in the pre- and post-test, and p-value of the comparisons of those conditions. The mean of flexibility in the post-test was significantly higher than that of the pre-test. Table 2 shows the descriptive statistics results (mean and standard deviation) as well as the p-values of the comparisons between groups, when pre- and post-tests data were analyzed together. A significant difference was not found between groups nor in the group-test interaction. Figure 1 shows the means of pre- and post-tests in the three groups, separately.

**Table 1 Descriptive statistics for total sample values in relation to the ROM variable in the pre- and post-test, and the p-value of the comparisons of those conditions.**

| Pre-test | Post-test | p-Value |
|---|---|---|
| 133.115±9.29 | 136.712±9.41 | 0.0095* |

* Significant difference

**Table 2 Descriptive statistics (mean and standard variation) and p-values of the comparisons between groups, when pre- and post-tests data were analyzed together.**

| | | p-Value |
|---|---|---|
| CG | 132.90±8.40 | 0.5696 (NS) |
| ETG | 133.758±9.25 | |
| SSG | 137.28±10.13 | |

(NS): non-significant
CG: control group
ETG: eccentric training group
SSG: static stretching group

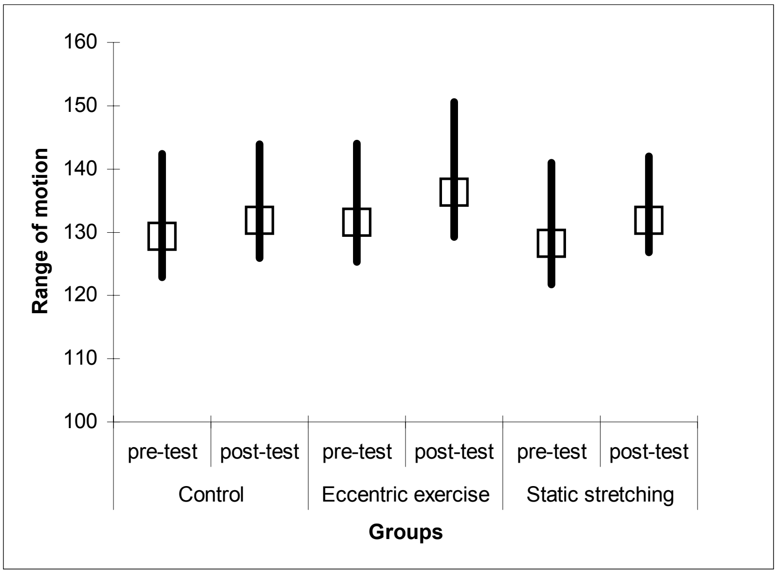


Figure 1: range of motion comparison in the pre- and post-tests between groups

**DISCUSSION:**

The critical analysis of the results demonstrates a probable tendency in increasing flexibility that was not statistically significant within groups because of small sample size (bellow the calculated *n* from previous studies) and large standard deviations.
This tendency in increasing flexibility was evident in the three groups, what was not expected considering the presence of a control group. One of the control groups subject reported a large loss of weight and this modification in body composition may have influenced the results, although not significantly. Probably, in a larger sample, minimal variations within groups would not be shown in statistical analysis. The 1 maximum repetition test carried out in the three groups could also have influenced an apparent increase in control group flexibility because of the functional and/or morphological changes imposed by this assessment procedure, as suggested by the study by Nelson and Bandy (2004). But the test was necessary in the control group to assure that this test was not the only responsible for flexibility gains in the SS and especially ET groups.
Opposed to what was expected as well as opposed to Nelson and Bandy's work there were no significant gains in flexibility in the ETG and SSG. There was although a tendency in increasing flexibility in the three groups. This increase was larger in the ETG (a mean increase of 5°), followed by the SSG (a mean increase of 3°) being the CG the group with a lesser mean increase (2°).
Both the stretching protocol and the ET protocol were considered adequate to induce an (non-significant) increase in flexibility, according to the consensus of *American College of Sports Medicine* (2002) to a systematic review conducted by Decoster *et al.* (2005). The SSG was the only group that had drop-outs and the authors believe that a longer protocol could result in even greater subject losses. A statistically significant gain in flexibility when the data was pooled in one single group strengthens the hypothesis that maybe both treatments are effective in increasing flexibility.
The major contribution of this study was utilizing a ET protocol that does not impose maximum range of motion opposing to the one used by Nelson and Bandy (2004) where the subjects were instructed to feel a sensation of "mild" stretching during ET execution. Future studies should assess the efficacy of these training methods proposed in the present study with larger sample sizes.
The increase in flexibility probably acquired due to ET could be explained by animal model studies that demonstrate that skeletal muscle has a large adaptation potential induced by eccentric exercise and that the morphological changes are related to addition of sarcomeres in series, according to Burtner *et al.* (1997) and Franllin (2003). Furthermore, Mjolsnes *et al.*

(2004) demonstrated that ET induced a larger strength gain in the hamstrings compared to concentric training. Proske *et al.* (2004) believe that these adaptations that occur with ET could possibly be a means of protection against muscle damage.

A progressive increase in strength was also observed in the ETG as shown by the increments in training load during the 6-week intervention, although no statistical analysis was carried-out as this analysis was beyond the scope of this study. This increase in strength and consequently a possible injury prevention benefit may be another reason the subjects should be eccentrically trained. Lastayo *et al.* (2000), showed that sub-maximum ET induces increases in cross-sectional area and isometric strength gains that did not occur in concentric training alone. Thus, ET could be a better prevention strategy against muscle strain when compared to SS, for being able not only of inducing length changes but also changes in strength and volume.

The ET protocol used in this study proved to be simple and likely to be used in clinical settings and in sports clubs. Other equipments and settings should be better evaluated in future studies. Future studies are also needed to determine if resistive training in general as well as a combination of ET and SS could induce flexibility gains and the magnitude of these changes if present. At last, other studies should assess the efficacy of these protocols in injury prevention and sports performance as well.

**CONCLUSION:**

No significant differences in flexibility gains between pre- and post-tests were observed in any of the groups, nor between groups. A tendency for increase in flexibility in the three groups was observed, and it was higher in the ETG. ET could be a more functional option for training since this type of training can prevent muscle injuries.

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