RANGE OF MOTION AND STRETCH TOLERANCE AFTER ECCENTRIC STRENGTH TRAINING

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The purpose of this study was to examine whether eccentric strength training alone and eccentric strength training combined with flexibility training of hamstring muscles can alter the maximum range of motion (ROM) and the stretch tolerance (ST) in the human hamstring muscles. Thirteen male (physical education students) performed strength eccentric training (Ecc) on one leg and eccentric and flexibility training (Ecc_F) on their other leg for 6 weeks; nine other subjects, not involved in any of these exercise performed served as a control group (CON). Strength and flexibility tests were administered before and after the training period. After 6 weeks of training, a significant difference between pretest and posttest was found for the one maximum repetition (1-RM) test on the Ecc and Ecc_F ($p<0,05$). The maximum ROM and ST increased significantly only in the Ecc_F group ($p<0,05$ for both). The results showed that the eccentric training alone was not able to enhance flexibility and modify stretch tolerance in hamstring muscle.

KEY WORDS: Eccentric contraction, Flexibility, Strength training, Hamstring muscle.

INTRODUCTION:

Strength and flexibility training are important components to improve athletic performance. Since specific training loads produce specific responses, it may be relevant to investigate whether the combined training of these mentioned components could have any concurrent effect upon one another.
Klinge et al. (1997) demonstrated that isometric strength training performed three times a week for 13 weeks modified the flexibility response resulting an increase in passive muscle stiffness. Although, when the isometric strength training was combined with stretching training any influence in the flexibility response was not observed. In contrast, eccentric strength training resulted in improving the hamstring flexibility, producing a gain of 12.8° in range of motion (ROM) (Nelson & Bandy, 2004).
The mechanisms associated with the increase of ROM are not well stabilished. The change in the material properties of the muscle-tendon unit (Taylor et al., 1990, Magnusson et al., 1995), the increase in both the stretch tolerance (ST) (Halbertsma & Goeken, 1994, Magnusson et al., 1996) and the sarcomeres number in series has been the mains mechanisms described. Thus, it is probable that the positive or negative interference of strength training in the flexibility response is associated with one of those mechanisms.
Recent investigations regard the muscle flexibility as a complex phenomenon and that its analysis requires the simultaneous measurement of the different parameters. The maximal joint ROM and ST can be considered as important variables of the flexibility assessment.
The purpose of this study was to examine whether eccentric strength training alone and eccentric strength training combined with stretching training of hamstring muscles can alter the maximum ROM and the ST.

METHODS:

Subjects: Twenty-two male subjects were randomly distributed between the groups: Nine in control group (CON; the mean ± SD for the age, height and body mass was 24.2 ± 5.2 years, 177.3 ± 6.8 cm, 75.1 ± 6.3 kg) and thirteen in training group (the mean ± SD for the age, height and body mass was 23.2 ± 2.4 years, 175.2 ± 3.9 cm, 74.5 ± 7.4 kg). All participants volunteered, after giving informed consent, for this study, which was approved by the local Ethic and Research Committee. The subjects had no history of knee, thigh, hip and low back impairments that contraindicate exercise. They had not participated in an organized strength or flexibility program in the previous 3 months.

Equipment: Hamstrings flexibility assessment and training were performed using the *flexmachine* (FIG.1). Similar equipment for this had been used in others studies (Magnusson et al., 1996, Chagas & Schmidtbleicher, 2001). The electrogoniometer was fixed on the axis of rotation of the mechanical arm for recording the ROM. To register the ST a device with on/of push button was held for each subject. The subject was asked to activate the push-button at the first sensation of tension or discomfort in the hamstring during the knee extension (stretch maneuver). The ST was registrated as a function of the ROM (ST_ROM). The equipment used to measure and to train hamstrings strength was the seated leg curl (Master Equipments, Brazil) (FIG. 2).

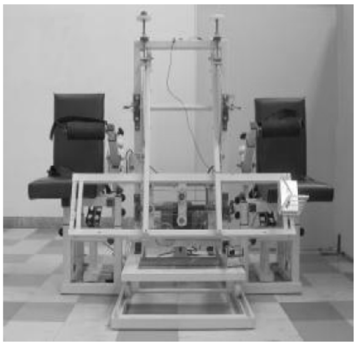

Figure1: Flexmachine

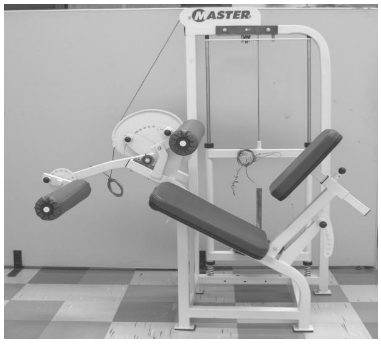

Figure 2: Seated Leg Curl Machine

Flexibility measurement: The maximum ROM was defined by the onset of the electromyogram (EMG) signal of the hamstring muscles (two times of standard deviation of baseline) during stretching maneuver. The electromotor was programmed with an angular velocity of 5º/s and the stretching procedure was repeated three times. The ST_ROM was recorded to indicate the ST.

Strength Testing: The one repetition maximum (1-RM) test was used as a measure of dynamic concentric strength of the hamstring muscles using seated leg curl machine. The 1-RM was determined with three to five attempts and was allowed a resting period of three to five minutes between attempts. The resistance was increased in incremental loads until failure occurred. The score of 1-RM test were used to determine the intensity of eccentric training.

Study design: The study design had one session of familiarization with a minimum interval of 48 hours of rest (no physical activity). After this it was done a pretest to assessment the flexibility (maximum ROM and ST_ROM) and strength performance (1-RM). So, the subjects were paired considering the maximum ROM and distributed in CON and training group. The training group was divided in eccentric training (Ecc) and eccentric training associated with flexibility training (Ecc_F). The right limb was chosen randomly to form the Ecc_F group. The sequence of evaluations of the lower limbs was maintained for the posttest. The volunteers were instructed not to participate in another strength or flexibility training during the study.

Strength and flexibility training: The eccentric training was performed three times per week for six weeks. The subjects executed three sets of 10-12 repetitions, 70%1-RM and two minutes-pause. Participants were instructed to perform each repetition in three seconds of duration and to achieve 90º ROM with each repetition of the exercise. The subjects were encouraged to increase the training load and another 1-RM test was carried after three weeks of training to control the training intensity. The flexibility training consisted of two sessions a week for six weeks. After the eccentric training, the subjects executed four sets of 20 seconds of passive static stretching with 20 seconds of interval between the sets.

Data Analysis: The reliability of the variables was verified with the intraclass correlation coefficient (ICC 3.1) and the method error (ME) (Sale, 1991). For this procedure both legs of the CON group were used. To compare the 1-RM performance between pre and posttest for CON, Ecc and Ecc_F groups was used the paired T-test. Repeated-measures analysis of variance (RMANOVA) was used to assess time effects and to determine if difference scores varied by groups. Variations in means difference scores were compared using the *Scheffé* post hoc analysis. An alpha level of $p<0.05$ was considered significant. The statistical procedures used the software Statistica 5.0.

RESULTS:

The analysis showed an ICC (3.1) and ME (%) of 0.935 and 6.8 for maximum ROM and of 0.948 and 12.7 for ST_ROM respectively. The training load increased significantly the 1-RM performance from the pre to posttest ($p<0.05$) only for the training group. The maximum ROM and ST_ROM values for all groups are shown in figures 3 and 4.

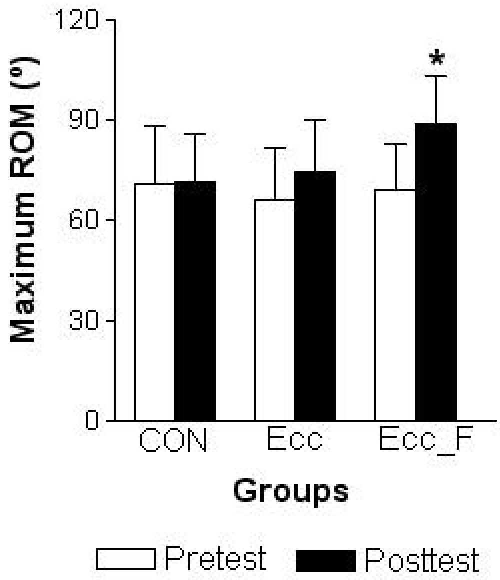

Figure 3: Maximum ROM (mean ± SD) in pre and posttest. * Different from pretest ($p<0.05$).

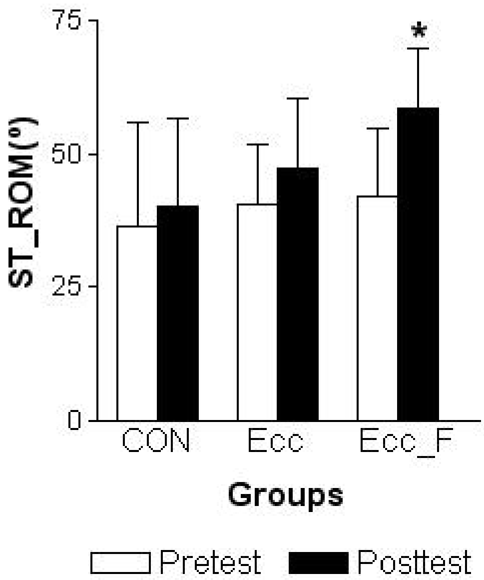

Figure 4: ST_ROM (mean ± SD) in pre and posttest. * Different from pretest ($p<0.05$).

DISCUSSION:

The 1-RM test results for the training group demonstrate that the eccentric training, three times a week for six weeks, is effective in increasing the hamstring strength corroborating with another previous study (Higbie et al., 1996).

There was no difference in maximum ROM in the Ecc group. This result is different from the one found out by Nelson & Bandy (2004) and by Lynn & Morgan (1994) who studied the effects of an eccentric training program. However, Koh & Herzog (1998) did not observed any increase in sarcomere number after eccentric exercise in rabbit dorsiflexor muscles. Therefore, the real effect of eccentric training on flexibility response remains unclear. A possible explanation for the contradictory results described above might be that the increase of maximum ROM depends not only on the eccentric muscle actions but also on the ROM in which the eccentric training is being performed. Nelson & Bandy (2004) oriented the volunteers to perform the eccentric training until a gentle stretch in hamstring groups was felt. In our study, even using straps around the legs and the pelvis to limit the knee flexion and

pelvic tilt respectively, the position that each subject performed the eccentric training could not have provoked even a gentle stretch sensation in hamstring muscles.
The data show that there was an increase in maximum ROM in the Ecc_F group. Since the gain in maximum ROM in the Ecc_F (19.9°) are quite similar to another study that trained only flexibility in similar equipment (Chagas & Schmidtbleicher, 2001), we concluded that eccentric strength training do not interfere negatively in programs to improve flexibility.
In our study the ST_ROM in the Ecc_F in pretest was 42.0º (±12.8) and 58.4º (± 11.1) in the posttest. In the Ecc no increase in ST_ROM was observed. Such finding indicates that an increase in extensibility of the hamstring muscles is a result of stretching exercise and it is influenced by an increase in ST of the subjects. We also hypothesized that changes of the nociceptors accommodation after a six weeks stretching exercise program alter the sensibility of the discomfort during the hamstring stretch.

CONCLUSION:

The eccentric training stimulus in the present study was not sufficient to produce changes in the flexibility response (maximum ROM and stretch tolerance). The addition of flexibility training to eccentric strength training did significantly change the maximum ROM and stretch tolerance. The results suggest that a concurrent effect between flexibility and eccentric training was not observed.

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