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Original Article

Acute Effect of Static Stretching in Agonist Muscle on the Levels of Activation and on Strength Performance of Trained Men

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ABSTRACT

The investigation of the effects of muscle stretching on the neural acute response has become a fairly attractive issue on current research when it is considered that strength performance is closely related to alterations on the levels of muscle activation. This study assessed the effects of 10 to 40 seconds of static stretching on the muscle activation as well as strength performance preceded by a repetition maximum test of trained subjects. 20 men, mean age of 21.75 (± 3.9), randomized in four groups according to the following stretching times: RT10s, RT20s, RT30s, RT40s – where RT corresponds to Resistance Training, were assessed. In the Control phase (C), the subjects were submitted to the repetition maximum test in the bench press with dumbbells exercise. In the Experimental Phase (E), they were submitted to static stretching with intensity of 10% of 1RM followed by the repetition maximum test. Muscle activation was assessed in the two phases with surface electromyography. One-way ANOVA was applied for statistical assessment, comparing anthropometric and functional characteristics of the groups, t test was used for paired samples, comparing control and experimental ones ($p < 0.05$). Results: Statistically significant differences have not been found ($p > 0.05$) in strength performance or levels of agonist activation when the different studied times and intensities in the (E) phase and the experiment with no stretching in the (C) phase were compared. Conclusion: Stretching exercise in the studied times and intensities does not seem to acutely affect the levels of activation in order to boost strength performance in a repetition maximum test. Therefore, different stretching intensities can be investigated with the aim to positively modulate these outcomes.

Keywords: static stretching, muscle activation, strength, performance.

INTRODUCTION

Muscle stretching exercise as a strategy to prepare for performance of physical exercise sessions associated to performance improvement as well as reduction of injuries is common; however, its influence is not well described in the literature[1].

The studies used to support this research, justifying this practice with the aim to improve performance, are still very controversial, especially concerning strength training sessions for muscle strength and power [2].

Specifically the use of stretching exercises searching for strength boost (*in vivo*) finds support in the prerequisite of reaching higher activation of the transversal bridges, since the experiments (*in vitro*) [3-5] demonstrated increase in contraction strength when the longitudinal spacing between actin and myosin is increased until certain levels.

In some studies (*in vivo*), negative effect of muscle stretching was verified in muscle strength and power performance, suggesting some intervenient factors, such as alterations in the viscoelastic properties of the musculotendinous units, reduction of activation of motor units and increase of musculotendinous complacence[6-8]. Further studies do not present any effect, either deleterious or positive, for muscle strength gain [9-11].

On the other hand, the current studies have been facing difficulty in measuring and reaching this possible anatomic stage with stretching exercises (*in vivo*) and hence, are still assumptions which need to be better investigated.

Therefore, the use of muscle stretching exercises as an activity responsible for reaching higher levels of muscle activation and consequently increasing strength production in the resisted exercises is not much explored.

However, despite these differences, we chose in this research to investigate (*in vivo*), the effects of different muscle stretching times on the activation levels as well as strength production in skeletal muscle.

METHODS

Subjects of the study –20 male subjects, mean age of 21.75 (± 3.49), trained for two to three months, who did not make use of any supplement were assessed. They were randomized in four groups according to the following stretching times for the Strength Training: 10, 20, 30 and 40 seconds, respectively RT10s, RT20s, RT30s and RT40s.

The experimental protocol – was approved by the Ethics in Research Committee (ERC) of the Southernmost Santa Catarina State University (UNESC) since it involved humans.

Control Phase – the subjects performed the anthropometric evaluations which followed standardization [12], for the calculation of body density, and mathematic model [7] for estimation of the fat percentage, electromyographic analysis[8], repetition maximum test[13].

Electromyographic analysis – bipolar configuration was used in this procedure, in which the two electrodes are placed over the muscle axis to be studied, and the third, termed ground wire, is located on a non-affected region (right ankle) and the electrical potential difference of the two electrodes is measured and the sum of the electric activity of all active muscle fibers of the pectoralis major muscle is picked, using as analysis value the Root Mean Square (RMS), having as reference the ground wire electrode.

Repetition maximum test – in this test the subjects were told to perform the maximum bearable repetitions until muscle fatigue identified by mechanical inefficiency to perform the movement in a single set in the dumbbell l bench press exercise having the maximum produced strength calculated [13] which proposes a mathematical model: maximum strength = load / 100% – (2 x number of repetitions performed).

Figure 1. Placement of the surface electrodes, bipolar configuration.

Figure 2. Performance of the RPM test with electromyographic analysis.

Experimental Phase – It was performed after 48 hours in which the subjects were submitted to static stretching with shoulder adduction in ventral decubitus with arms completely extended having the pectoralis major as agonist muscle where amplitude respected the maximum degree of discomfort performed in a single movement remaining statically by the time previously set. Two dumbbells corresponding to 10% of 1RM of the resisted exercise of shoulder adduction abduction were used to assess resistance in ventral decubitus with semi-flexed elbow calculated according to a protocol [13].

Figure 3. Performance of static stretching in ventral decubitus.

Subsequently, the subjects were submitted to the repetition maximum test in the dumbbell bench press exercise and electromyographic analysis which followed the same criteria of control phase, performing 30 seconds of interval between the stretching exercise and the test.

Experiments handling – The assessment control and experimental phases were handled by the same evaluators (three), the evaluations were individual; that is to say, the evaluators and the subject at the same times in the Laboratory of Biomechanics of the Physiotherapy Clinic of UNESC. No previous warm-up was allowed.

Statistical analysis – The descriptive data were presented with mean and standard deviation. After randomization of the anthropometric characteristics, strength performance as well as of the levels of activation in the control phase were compared by one-way ANOVA. Strength performance and activation levels in the control and experimental phases were compared by the ***t*** test for paired samples with significance level ($p < 0.05$).

RESULTS

Table 1 presents the characterization of the subjects regarding: age (years), stature (cm), body mass (kg), lean body mass (LBM) in kg, body fat percentage (F%), strength performance and activation levels in RMS expressed in micro Voltz (µV) in the control phase.

The results obtained in the sample characterization do not present statistically significant difference ($p > 0.05$) suggesting homogeneity between groups, which qualifies the comparison of results of the control and experimental phases between groups.

Table 2 presents results of the maximal strength performance in the control and experimental phases kgf.

Comparing strength performance in the control phase with the experimental phase no statistically significant difference was found,

Table 1 Demographic characterization of the subjects in mean + standard deviation in the groups: (RT10s) Resistance Training Group with 10 seconds of stretching, (RT20s.) Resistance training with 20 seconds of stretching, (RT30s.) Resistance training Group with 30 seconds of stretching, (RT40s.) Resistance Training Group with 40 seconds of stretching. (LBM) Lean Body Mass, (F%) body fat percentage. (RMS) Root Mean Square, (p>0.05) significance level.

Variáveis	TF10	TF20	TF30	TF40	(p > 0,05)
Age	22.8 (± 3.49)	24.2 (± 3.96)	19.6 (± 1.51)	20.4 (± 3.28)	-0.1
Weight	69.18 (± 9.05)	70.52 (± 11.78)	68.26 (± 9.46)	71.38 (± 9.13)	-0.89
Height	173 (± 4.38)	174 (± 7.4)	177 (6.11)	178 (6.43)	-0.58
LBM	59.63 (± 5.03)	59.71(± 6.30)	61.03 (7.26)	61.33 (6.78)	-0.99
F%	13.4 (± 4.25)	14.8 (± 6.14)	10.7 (3.63)	14 (2.25)	-0.41
Strength	76.03 (± 15.48)	91.12 (± 34.13)	88.29 (44.89)	80.79 (44.70)	-0.91
RMS	11.489.2 (± 2.522)	13.367.4 (± 7.310)	14.440.2 (6.653)	13.476.8 (4.932)	-0.8

Data are presented in mean + standard deviation. Subtitles: (RT10s) Resistance training group with 10 seconds of stretching, (RT20s.) Resistance training group with 20 seconds of stretching, (RT30s.) Resistance training group with 30 seconds of stretching, (RT40s.) Resistance training group with 40 seconds of stretching. (LBM) Lean Body Mass, (F%) body fat percentage. (RMS) Root Mean Square, (p>0.05) significance level.

Table 2. Strength behavior in control and experimental phases in mean+ standard deviation in the groups: (RT10s) Resistance Training Group with 10 seconds of stretching, (TR20s.) Resistance Training Group with 20 seconds of stretching, (RT30s.) Resistance Training Group with 30 seconds of stretching, (RT40s.) Resistance training Group with 40 seconds of stretching, (p>0.05) significance level.

Group	Control strength	Experimenta strength	(p > 0,05)
RT10	76.03 (± 15.48)	76.02 (± 25.29)	(p > 0. 99)
RT20	91.12 (± 34.13)	76.47 (± 25.87)	(p > 0. 50)
RT30	88.29 (84.49)	70.97 (± 14.92)	(p > 0. 45)
RT40	80.79 (40.70)	66.83 (± 23.65)	(p > 0. 53)

Data are presented in mean + standard deviation. Subtitles: (RT10s) Resistance Training Group with 10 seconds of stretching, (RT20s.) Resistance Training Group with 20 seconds of stretching, (RT30s.) Resistance Training Group with 30 seconds of stretching, (RT40s.) Resistance Training group with 40 seconds of stretching, (p>0.05) significance level.

suggesting hence that the static stretching exercise had no effect over the strength performance in the stretching times studied.

Table 3 presents performance results of the activation levels in RMS expressed in micro Voltz (μV) in the control and experimental phases.

Table 3. Behavior of the activation levels in RMS expressed in micro Voltz (μV) in the control and experimental phases in the groups: (RT10s) Resistance Training Group with 10 seconds of stretching, (RT20s.) Resistance Training Group with 20 seconds of stretching, (RT30s.) Resistance Training Group with 30 seconds of stretching, (RT40s.) Resistance training Group with 40 seconds of stretching, (p>0.05) significance level.

Group	control RMS	experimental RMS	(p > 0,05)
TF10	11.489.2 +2.522. 7	12.311.2 +4.269. 8	(p > 0. 72)
TF20	13.367.4 +7.310. 9	13.033.2 (+5.758)	(p > 0. 75)
TF30	14.440. 2 +6.653. 1	14.356.8 +5.320. 7	(p > 0. 77)
TF40	13.476.8 4.932. 4	15.715 +11.341. 7	(p > 0. 83)

Data are presented in mean + standard deviation. Subtitles: (RT10s) Resistance Training Group with 10 seconds of stretching, (RT20s.) Resistance Training Group with 20 seconds of stretching, (RT30s.) Resistance Training Group with 30 seconds of stretching, (RT40s.) Resistance Training Group with 40 seconds of stretching, (RMS) Root Mean Square, (p>0.05) significance level.

When the performance results of the activation levels in the control and experimental phases were assessed, statistically significant differences have not been observed, suggesting that the static stretching exercise in the performed intensity did not present effect over the muscle activation levels in any of the studied times.

DISCUSSION

Studies have demonstrated the acute deleterious effect of muscle stretching exercises in strength performance comparing warm-up with no stretching in the control phase and static stretching associated with the warm-up process in the experimental phase being: static stretching + running; static stretching + specific exercises in the experimental phase. The results demonstrated that the lower values in production of explosive strength were found when preceded by static stretching exercises in the warm-up process; however, when the results of the experimental phase were compared, the highest values in explosive strength performance were found in stretching + specific exercises [9-11,14,15].

The comparison of different ways of stretching presented lower values for stretching with proprioceptive neuromuscular facilitation (PNF) than for static stretching [9]. The PNF was performed remaining passively in static position for 20 seconds, followed by maximal isometric contraction during 10 seconds; subsequently, a stretching set was performed searching for amplitude until the maximum pain threshold, hence one with high intensity.

In another investigation [10] for the 1RM test in the leg press exercise, significantly lower results were found for the individuals who had performed a static stretching session with 20-minute duration before the test, in comparison to the individuals who performed the test with no stretching protocol.

These findings were also described in other studies [11] which verified deleterious effect on the peak torque, muscle power and electromyographic responses in the knee extensors when preceded by the static stretching method and proprioceptive neuromuscular facilitation (PNF) using in their protocols maximum bearable discomfort.

Close results [15] which demonstrated attenuation in vertical jump performance when it was preceded by static stretching exercises were found. Nonetheless, the electromyographic responses of the gastrocnemius muscle were increased, being this fact a clashing result in this study.

Although some studies [9,11,14,15] assess muscle power and the present study assesses dynamic strength, and this factor significantly differentiates the muscle activation mechanisms, we highlight the intensity of the stretching at which the authors used subjective parameter of maximum bearable discomfort, which suggests maximum tension over maximum stretching amplitude.

Differently from the present study which was carried out by the quantification of the intensity in 10% of 1RM of iron cross resistance exercise with the same biomechanics in the eccentric phase of the static stretching exercise used.

Thus, it is suggested that controlling intensity from 1RM percentage results may be a strategy with an important role in the modulation of the results for dynamic strength and that can be investigated in further studies assessing muscle power.

Nevertheless, when the variable stretching time is assessed, the results suggest it is not a crucial factor when performed between 10 and 40 seconds with a single session, since in this study no difference was observed between groups. Such analysis is stressed when the studies' protocol[8,13,14] and of the studies[1,9,10] which used different stretching times and similar intensity are compared and presented close results.

On the other hand, the session time as well as the number of stretching sets seem to negatively influence strength performance as shown in another study [8].

Other authors [16-22] did not demonstrate significant difference in performance of dynamic strength with muscle stretching as a study performed which assessed muscle strength after static and dynamic stretching of 30 seconds through the leg extension exercise and did not find difference between the group which performed static stretching and the control group [16].

The acute effect, similar to the static stretching assessing 11 subjects submitted to 30-second static stretching for lower limbs, compared to the warm-up alone performed through 20 repetitions of the exercise with light load previously to the performance of a 10RM test in the leg press 45° exercise, being respected 48 hours of interval between the tests application, did not find statistical difference between the stretching exercise and the specific warm-up prior to the test [17].

The effect of two warm-up protocols compared to the static stretching exercise alone in a 1RM test in the leg press exercise, in which 10 minutes of aerobic exercise with intensity of 60-80% of maximum heart rate was used for group 1; group 2: specific warm-up with 20 repetitions with light loads; and group 3: six stretching exercises of a 10-second set until pain threshold for the muscle groups involved in the test [18]. In conclusion, no significant strength difference was observed in the different studied protocols.

In another study [19] higher volume of repetitions was also verified but no significant differences were found in the maximum number of repetitions in the bench press exercise with 80% of 1RM using two distinct protocols. The first was characterized by the performance of 15 repetitions with 40% of load of 1RM of the exercise, and the second was composed of three stretching exercises for the muscles involved in the bench press in one set, with tension time of 20 seconds.

The strength production after passive stretching exercises of 20 seconds and specific warm-up with volume of 15 repetitions with 50% of 10RM load, analysis performed through the volume of repetitions in three sets not finding statistical difference between the stretching and warm-up protocols [20].

The influence of the PNF compared to specific warm-up in muscle strength performance through the 1RM test in the bench press exercise [21]. The specific warm-up was performed with two sets of 20 repetitions with light loads adopting 30 seconds between sets. The PNF stretching led the movement to maximal threshold held for six seconds, followed by five seconds of isometric contraction and subsequent stretching for six seconds at maximal threshold held. Significant differences have not been observed in the loads used in the 1RM test between the PNF stretching and the specific warm-up.

Close results were found [22] not showing differences in the jump performance using the PNF stretching and the static stretching, in which the PNF was performed with a submaximal isometric contraction of five seconds of the agonist muscle followed by passive stretching of 15 seconds.

When the results of the present study are compared to the ones in the literature, we observed that part of the findings described by part of the literature [16-22] since it does not present significant difference in dynamic strength performance.

Therefore, although there is evidence suggesting that the variable intensity can be able to modulate the results of muscle activation, the studies until the present moment are insufficient to describe a stretching strategy able to alter the neural factors able to reach activation levels which reflect on improvement of muscle strength performance as well as muscle power.

CONCLUSION

The results presented in this study demonstrate that the static stretching exercise did not negatively alter the activation levels and strength performance in a repetition maximum test at the intensity performed, suggesting that there is no difference between performing or not static stretching previously to the repetition maximum test.

These outcomes should not contraindicate performance of static stretching in the resistance exercise sessions which focus on dynamic strength improvement, since this study, as well as great part of the literature, assessed performance at dynamic strength and muscle power test situations and hence, are not conclusive for a training session, remaining open to further studies on this effect.

The results of the current literature, despite being conflicting until the present moment seem to sign to a consensus; the static muscle stretching exercise does not seem to alter dynamic strength performance or negatively alter muscle power performance.

Thus, the evidence suggests that further studies should be carried out in order to assess different intensities of stretching trying to modulate the negative results for muscle power.

All authors have declared there in not any potential conflict of interests concerning this article.

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