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EFFECTS OF DIFFERENT INTENSITIES OF FLEXIBILITY TRAINING ON EXPLOSIVE FORCE

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ABSTRACT

Purpose. To verify whether there are changes in the performance levels of the explosive force when the same muscle group previously underwent different intensities of flexibility training (stretch & flex). **Basic procedures.** The tests were performed with 25 females on three consecutive days and were preceded by a 10-minute warm-up period. First, each participant performed a maximum vertical jump on a contact platform. The jump was repeated after 10 minutes, and the first day was considered the control (C). On the second day, a routine of stretching exercises (S) was included, and on the third day, the same routine, but intensified with a maximum static stretching exercises (flexibilizing – F), was used. **Main findings.** The height reached in the control jump decreased by 0.17%, showing no influence on the performance when the jump happened on the same day, with a time-interval of only 10 minutes (p = 0.903). On the day of the stretching routine, there was a reduction of 3.6% (p = 0.001), and on the third day with flexibilizing, there was a 6.8% reduction (p = 0.001). A comparison of the groups showed no significant differences between them. **Conclusions.** The jumps after the two stretching routines were significantly lower. Submaximal or maximal (flexibilizing) stretching exercises reduced the explosive force of vertical jumps, although the differences between the training intensities were not significant.

Key words: flexibility, stretching, warm-up, vertical jump

Introduction

Flexibility is an element of physical fitness, which particularly determines an individual's wholesomeness and independence [1]. Like other physical features, flexibility may be trained at submaximal intensity (stretching), performed within the normal range of motion and slightly forcing for 4 to 6 seconds, or at the maximal intensity (flexibilizing), performed with discomfort on the pain threshold for at least 10 to 15 seconds. In flexibility training, ballistic, proprioceptive neuromuscular facilitation (PNF), and static methods are traditionally used, with the latter having greater applicability [2].

Flexibility training has been used by athletes to prevent lesions and enhance athletic performance [2–4]. Nevertheless, its use in isolation as preparation for exercise is unlikely to prevent lesions and may even hamper performance in sports involving strength and power [5].

Static flexion prior to physical activity has been shown to reduce force production and power output [6–9], inhibit dislocation speed [10]. Likewise, Bezerra et al. [11] have demonstrated that PNF exerts a negative acute influence on force resistance. On the other hand, there are investigations pointing to a favorable influence of stretching exercises on performance [3, 12, 13]. On the other hand, the results with constant training in sports without stretching also decrease maximal power output of lower extremities [14].

These results may be conflicting due to the lack of intensity standardization of flexibility training. Therefore, the aim of this study was to investigate changes in the performance levels of explosive force in young adult women when the same muscle group previously underwent flexibility exercises (stretch & flex) of different intensities.

Material and methods

Subjects

Twenty-five active in strength training adult women (aged 28.2 ± 3.5 years; height 162.2 ± 1.4 cm; body

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mass 56.9 ± 1.1 kg) volunteered for the study. The inclusion criteria were the absence of lesions and the ability to perform vertical jumps and flexibility exercises. All the participants had in their physical exercises programs, besides those for strength and cardiorespiratory resistance, one section that dealt with stretching, being performed at least three times a week. The participants were instructed to avoid intense physical activity 48 hours before each training session. Their flexibilities were assessed with a 360° steel goniometer (Cardiomed, Brazil) to ensure they had a healthy range of motion for hip joint extension (HE) and flexion (HF).

The volunteers signed an informed consent form according to both the 196/96 resolution of the Brazilian National Health Council and the 1975 Helsinki Declaration. The study was approved by the Ethics Committee of the Castelo Branco University (UCB/RJ), under the 0004/2008 protocol.

Procedure

The tests, preceded by a 10-minute warm-up in a stationary cycloergometer (Movement Summer G2, Brazil), were intended to make the subjects reach a heart rate which was 60% of the age-adjusted maximal heart rate (MHR) [15]; these tests were performed on three consecutive days. On the fist day, the participants performed a maximum vertical jump (start jump), with the highest three results recorded. This was repeated after a 10-minute interval, without any training routine. This was the control (C). On the second day, a routine of submaximal stretching exercises (S) for 10 minutes was added. The same routine was repeated on the third day, but this time with intensity variation and the use of maximum static force (flexibilizing – F); this was performed with the same duration as in the previous two days. Figure 1 shows the procedures performed on the three days.

Jump heights were measured on a contact platform (Jump Test Pro, Ergojump, Brazil), and the countermovement jump (CMJ) technique was used. According to this technique, the preparatory movement for the jump is one in which the start position is standing with the hands fixed on the waist and the feet as wide apart as the shoulders and parallel to each other. The hip, knee, and ankle joints are then flexed before the actual jump is performed.

During the stretching routine (S), the movements were slowly performed until the normal limit of the range of motion was reached, and then this position was sustained for 10 seconds. A manual tonometer

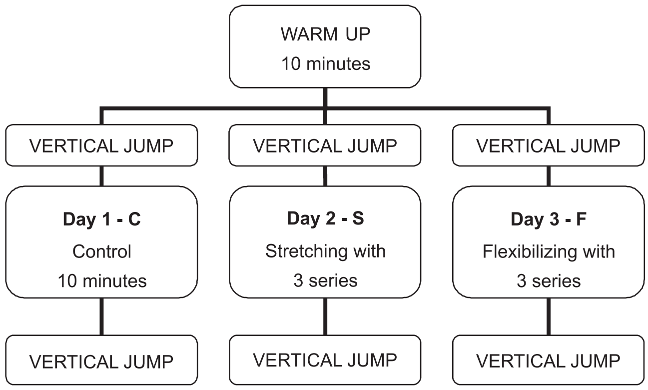


Figure 1. Diagram of test routines

(muscle test system – model 01163, Lafayette, LA, USA) was used to measure the pressure over the flexed body segment, with the device placed on the distal end of the limb being assessed and the reading obtained in the 10th second of posture adoption.

The movements performed were supine hip flexion with extended knee (HF); supine ankle dorsiflexion (DF); and prone knee flexion.

For the flexibilizing routine (F), the same movements were performed with greater pressure, i.e., greater intensity. Table 1 illustrates the pressures recorded for the two routines, along with the differences between them in percentages.

Table 1. Force used in the flexibility exercises routine

Flexion movements	Stretching (kgf)		Flexibilizing (kgf)		Delta %
	Mean	SD	Mean	SD	
Hip	4.28	1.33	7.25	1.24	69
Ankle	7.01	3.17	14.77	4.56	110
Knee	9.56	3.94	15.19	4.34	59

Statistical analysis

The SPSS 14.0 for Windows and Statistica packages were used for the calculation of the means and standard deviations. For data normality verification, the Shapiro-Wilk and Levene tests were used, with the following p values showing homogeneity of the collected data: C1 = 0.986; C2 = 0.442; S1 = 0.303; S2 = 0.552; F1 = 0.849; and F2 = 0.448.

For inferential statistics, a paired t-test for intragroup comparison was used. A 3x2 ANOVA and repeated measures ANOVA with two factors (routine × pre-post) were applied, followed by Tukey's post hoc test for inter-group comparison. To compare the percentage and absolute differences and the ratio index*, a one-way ANOVA was used. Statistical significance was considered at $p < 0.05$.

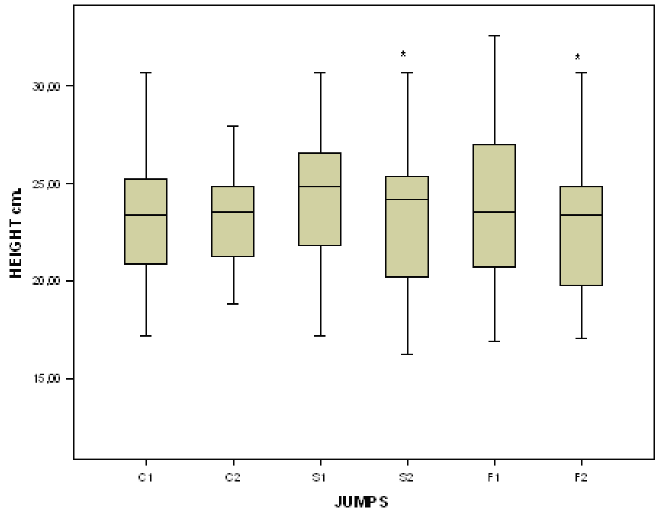
Results

Goniometry results (102.5 ± 15.4° for hip flexion, and 44 ± 11.4° for hip extension) indicated that the participants were within the standard mean range according to the Academy of Orthopedic Surgeons, Kendall & McCreary, Hoppenfeld, and the American Medical Association.

The exercise intensity was significantly different between the stretching and the flexibilizing, which raises the possibility of an intensity change in the case of flexibility training.

The height reached in the control jump was 23.4 ± 4.3 cm for C1 and 23.3 ± 3.5 cm for C2; this indicates an absence of influence on the performance when the jumps were performed on the same day with a 10-minute interval only ($p = 0.903$). On the day of the stretching routine, the results were: 24.3 ± 3.7 cm for S1 and 23.4 ± 3.8 cm for S2 ($p = 0.001$). On the third day, which was reserved for greater intensity of the flexibility exercise (flexibilizing), the results were: 24.3 ± 4.1 cm for F1 and 22.6 ± 3.8 cm for F2 ($p = 0.001$). Figure 2 shows these results. The jumps performed after the two flexibility routines were significantly lower. In comparison between the groups, there were no significant differences.

The relative difference ($p = 0.001$), the absolute difference ($p = 0.003$), and the ratio index (0.002) were all statistically significant according to the one-way ANOVA. Tukey's post hoc analysis showed that the percentage difference was only significant when the control (C) and flexibilizing (F) groups were compared ($p = 0.001$). The same was found for the absolute difference ($p = 0.002$) and for the ratio index ($p = 0.001$).



C1 – control pre
C2 – control post
S1 – stretching pre
S2 – stretching post
F1 – flexibilizing pre
F2 – flexibilizing post
* significant differences

Figure 2. Comparison between the height reached in the vertical jumps, before and after control jumps, and the two routines of flexibility exercises

Discussion

This study was undertaken to compare the effect of two routines of flexibility exercises on the performance of the vertical jump, with the application of two distinct intensities. The differences were verified and a $p < 0.05$ was found for the three movements applied. Because quantification of the intensity of flexibility exercises was feasible, the method may be useful for standardization in future experiments.

The reductions found in the performance of vertical jumps after the two flexibility routines were not significant. This is in agreement with other studies, which also indicated a non-significant fall in the heights of vertical jumps as a result of lower limb stretching [16, 17].

Cramer et al. [18] investigated the effects of static stretching at the peak of concentric and isokinetic torque, with leg extension at 60° and 240°/s, in the stretching limb (dominant) and relaxing limb (non-dominant) of 14 recreationally active women. These authors also noticed a non-significant reduction of the peak torque in both limbs and at both speeds (60° and 240°/s) using 4 series and with the posture sustained for 30 seconds. Although there was force reduction, this was not significant, even with the intensity increase. In our experiments the posture was sustained for 10 seconds only; maybe this fact has made the difference in results.

Likewise, Giordano et al. [19] investigated the difference between a Proprioceptive Neuromuscular Facilitation (PNF) routine and a warm-up that did not involve flexibility in eight American football players (age range 18–20 years); they did not find any significant

* It is a mathematical form of normalization in which the value of the post-test is divided into in the pre-test value, and when this value is superior to 1 it means that the post-test was greater than the pre-test, and vice-versa.

difference between the performance of vertical jumps. The motor action was the same as in the present study. Likewise, Little and Williams [16] did not find any significant reduction in the countermovement vertical jump when they investigated the acute effects of static and dynamic stretching as a warm-up prior to power and agility activities in 18 soccer players, with the posture sustained for 30 seconds for each flexion.

Our results are in agreement with those of Young and Elliot [20], who compared the acute effects of static stretching, PNF, and maximum isometric contraction on the production of explosive force and vertical jump in 14 men. These authors noticed a significant reduction of the jump with a fall after static stretching compared with the other conditions, even involving athletes who were accustomed to sports involving jumps. These findings may be due to a more intense training method, the PNF. Conversely, Bradley et al. [21] compared the acute effects of static stretching, ballistic stretching and PNF on the vertical jump performance of 18 male undergraduates and determined that the duration of this effect was up to 60 minutes, using 5 exercises in 4 series with the posture maintained for 30 seconds; they found only a 5% reduction after static stretching and PNF.

It is noteworthy that studies like ours have involved moderate routines of static stretching prior to the performance of vertical jumps, and no significant changes in the values of the vertical jumps were found [6, 22].

The method used in this study showed that stretching exercises may be applied at different intensities, thus being amenable to individualization according to each training type and even having the potential of being used (in a modified way) on competition days. The force applied on the stretched limb does not seem to be the most important factor in intensity change. Thus, a limitation of this study, the variation in the number of series or the time the limb is sustained in each position, may also be of interest.

Conclusions

Stretching exercises at submaximal and maximum (flexibilizing) levels reduced the explosive force of vertical jumps, although the difference between the intensities was not significant when the intensities were compared. However, the difference was significant when flexibilizing (F) in isolation was considered. In comparison between the groups, there were no significant differences. Professional coaches involved in flexibility training should be cautious when applying a maximum or submaximal stretching routine for their athletes or students.

It was noted that the influence of the methods of flexibility training conducted immediately before the commencement of physical activities and competitions are controversial in relation to its effects. With a need for research into different methods and different volumes and intensities and studies with biochemical interventions, as well as longer sustaining times in each position, are warranted.

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