INFLUENCE OF STRETCHING EXERCISE ON PERFORMANCE AND MOVEMENT TECHNIQUE DURING DROP JUMPS

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The aim of this study was to verify the influence of a single flexibility training session on drop jump performance (vertical velocity at take off) and movement technique (joint angles and joint angular velocities). Thirty male subjects performed two drop jumps before and after four sets of quadriceps static stretching. A control session was made without stretching. The results showed an increase in ground contact time, an increase in knee and ankle joint flexion as well as an increase in knee maximal angular velocity during the eccentric and concentric phases. However, these changes in the movement technique have not affected the performance.

KEY WORDS: stretching, performance, movement technique, drop jump.

INTRODUCTION: Many sport movements consist of a particular combination of contraction types called the stretch-shortening cycle (SSC) and most commonly, the SSC has been studied in jumping. The Drop Jump (DJ) consists mostly of this type of contraction and is used to evaluate the power of the lower limbs (Brown and Weir, 2001). The resulting performance on this test has been correlated with athletic performance (Young et al., 2002). It is important to know if flexibility training before activites which use SSC will lead to changes in performance and movement technique.

Studies about the influence of stretching on multiple joint and dynamic power activities have shown different results (McBride et al., 2005). The negative effect of stretching on maximal isometric (Weir et al., 2005) and concentric strength (Nelson and Kokkonen, 2001) is more consistent when these parametres are investigated using single joint tests.

Young and Elliott (2001) reported performance reduction on DJs after static stretching, however no changes concerning the performance were observed after stretching with the proprioceptive neuromuscular facilitation (PNF) technique. Other studies have reported no changes on performance of this vertical jump technique after static and balistic stretching, despite the reduction on maximal strength in a single joint test (Power et al., 2004; Unick et al., 2005). However, in these studies no specific flexibility tests were applied in order to evaluate the efficiency of the proposed stretching exercises concerning muscular lengthening.

Changes on kinematic parameters (angles and angular velocities) during eccentric and concentric actions in DJs have been received little attention and could provide important information about changes in movement technique induced by stretching. The purpose of this study is to analyze the acute effect of quadriceps stretching on DJ performance and movement technique.

METHODS:

Study Design: Thirty male physical education students (age: 24,6 ± 4,4 years; body mass: 71,2 ± 8,2 kg; height: 175,3 ± 7,2 cm) performed DJs in two different sessions: before and after a quadriceps stretching program (experimental session) and before and after a 20 minutes rest period (control session). The experimental session and control session were interspersed with a 24 hours rest and the order was randomized. Five sessions of DJ training were performed two weeks prior to the data collection in order to familiarize the volunteers to this jump technique. Each subject performed the DJ at his optimal individual height, determined through the best performance index (height of the centre of gravity/contact time). Three attemps from each drop height (20, 30, 40 and 50 cm) were performed in order to set up the optimal height.

Data Collection:
Kinetic Data: A force platform (AMTI OR6-7) was used to measure the vertical ground reaction force (1000 Hz). The force-time curves were acquired with the software SIMI Motion 7.2 and analyzed with DasyLab 4.0. The A/D converter used was from Data Translation (DT9800-EC). The performance was evaluated using the vertical velocity at take off (V), which was calculated from flight time. The contact time (CT) was obtained using the force-time curve. The average of two attempts was used for analysis.
Kinematic Data: Sagital-view kinematic data were collected using a digital video camera (Canon ZR300, 60Hz) and the images were acquired and analyzed with the software SIMI Motion 7.2. Reflective markers were placed on the right side of the subject (fifth metatarsal, lateral malleolus, lateral epicondyle of the femur, greater trochanter and the acromion process). The analyzed variables were: ankle and knee angles at the greatest dorsiflexion angle ($A_{DF}A$, $A_{DF}K$) and maximal ankle and knee angular velocities at eccentric ($V_{max}EccA$, $V_{max}EccK$) and concentric phases ($V_{max}ConA$, $V_{max}ConK$). The average of two attempts was used to analysis.
Flexibility Evaluation: The Range of Motion (ROM) was evaluated with a knee flexion test. The test was executed with the subject lying prone on an instrument (Quadriceps Stretching Bench - QSB) and a Leighton flexometer (model 01146) was fixed at the tested lower limb (LL) to measure the knee flexion ROM. The non tested LL was fixed at 90º of hip flexion and a wooden platform was adjusted on the subject pelvis, to avoid the anterior pelvic tilt. The tested LL started the test from the initial position of 90º of knee flexion and the subject performed a slowly active knee flexion, until the maximal ROM, which should be maintained for two seconds approximately. The average of three attempts was calculated to data analysis. The intraclass correlation coefficient (reliability) of intratester ROM measures is 0,96 using this procedure.

A B

Figure 1: Initial (A) and final position (B) during the knee flexion test.

Stretching was done at the QSB and the subject position was the same adopted during the flexibility test. Four passive static stretching sets of 20 seconds were performed until the point of discomfort and the interval between the sets was 20 seconds.

Statistical Analysis: Because this was a within-subject study design, group data was compared between pre and post intervention for each session (experimental and control) using paired *t*-tests. The level of significance was set at $p < 0,05$ and the statistical package used was the SPSS for Windows, version 11.0.

RESULTS: The stretching training resulted in a significative increase of aproximately 6º on the knee flexion ROM (pre = 30,9º ± 8,7; post = 36,8º ± 8,6).

Means and standard deviations for all variables on both sessions are shown in Table 1.

Table 1 Means and Standard deviations on experimental and control sessions

	Experimental Session		Control Session	
Variables	**Pre**	**Post**	**Pre**	**Post**
V ($m.s^{-1}$)	2,12 ± 0,27	2,13 ± 0,31	2,14 ± 0,30	2,10 ± 0,29
CT (ms)	211 ± 20	223 ± 25*	214 ± 18	211 ± 21
$A_{DF}A$ (º)	94,3 ± 5,7	92,8 ± 4,0*	93,5 ± 4,9	93,5 ± 4,2
$A_{DF}K$ (º)	115,7 ± 6,9	113,8 ± 7,2*	115,8 ± 7,2	116,6 ± 7,7
$V_{max}EccA$ (º/s)	537,0 ± 78,8	551,2 ± 77,5	536,5 ± 79,7	543,8 ± 79,9
$V_{max}EccK$ (º/s)	363,4 ± 81,6	380,4 ± 83,3*	374,1 ± 79,3	365,8 ± 86,7
$V_{max}ConA$ (º/s)	580,8 ± 49,2	564,8 ± 46,7	571,9 ± 54,5	567,9 ± 50,9
$V_{max}ConK$ (º/s)	526,5 ± 62,9	541,8 ± 65,8*	532,8 ± 72,2	528,8 ± 69,5

* Significant difference between pre and post intervention ($p < 0,05$).

DISCUSSION: The present study did not report any changes in performance, which is contradictory to the study made by Young and Elliott (2001). A possible explanation to this divergence could be related to the diffentent criteria adopted to define performance. Whereas this study used the velocity at take off to analyze this parameter, Young and Elliott (2001) used the jump height/contact time score. In addition, the greater number of muscular groups that were stretched could have contributed to the divergence of our results. However, Power *et al*. (2004) used a greater total stimulus duration (540 seconds), with stretching of three muscular groups, and did not find any significant change in jump height or contact time. Unick *et al*. (2005) also reported no modification in the jump height after a total period of 180 seconds stretching of four muscular groups, but the contact time was not controlled.

In this study, the performance did not change, however, an increase in ground contact time and in joints ROM during the eccentric phase was observed. A possible stiffness reduction of the muscle-tendon units (MTUs) could lead to a necessary increase of the eccentric phase in order to absorb the mechanical load. The stiffness can be regulated by changes in the tissues' mechanical properties and the level of neuromuscular activation. As stated by to Komi (2003), the stiffness regulation is extremely important to the eccentric phase of DJ and stretch reflexes play a fundamental role in this task.

Despite Kubo *et al*. (1999) have suggested that compliant MTUs are advantageous to the performance of slow SSCs, stiffer MTUs seem to benefit faster actions as the DJ. In such movement, a fast transmission of muscular force to the bones is necessary. According to Finni *et al*. (2001a), during the eccentric phase of DJs, a greater strain is observed in the tendons, and thus, these structures play an important role in the storage and reutilization of elastic energy. However, the force production in the concentric phase is maximized only if there is no delay on the transision between the eccentric and concentric phases. For this reason, stiffness reduction induced by neural or miogenic factors could lead to performance decrease, due to the increase in the transition time between the movement phases.

To maintain a short time between the eccentric and concentric phases, the joints' ROM has to be controlled. Greater knee and ankle flexion were observed, leading to an increase in the contact time. It was also observed an increase in the knee maximal angular velocity during the eccentric and concentric phases. During the eccentric phase, the existing increase could be connected to the reduction in stiffness and incapacity to absorb the mechanical loads. However, during the concentric phase, the increase in the maximal angular velocity could suggest that a change of stiffness induces control strategies, modifying the movement technique in order to maintain the best performance as possible.

Various studies that analyzed the importance of stretching reflexes during DJs used the triceps surae as investigation source. Finni *et al*. (2001b) showed that Achilles and Patellar tendons have different behavior during jumps with different knee joint angular displacement. During DJs with small knee joint displacement, Achilles tendon forces are greater than Patellar tendon forces, whereas during movements with large knee amplitudes, an opposite behavior has been observed, with greater Patellar tendon forces. This points out that the function of different MTUs is not the same during all the SSC activities and thus general conclusions can not be made from one single muscle.

CONCLUSIONS: In this study, four sets of quadriceps static stretching induced changes in the movement technique (increase in dorsiflexion and knee flexion amplitude, increase in the knee maximal angular velocity) and an increase in contact time. However, it was not observed any change in the vertical velocity at take off, resulting in the same performance. Therefore, no indication of excluding stretching exercises before DJs, concerning the reduction of performance, could be made. It is necessary that future studies will be performed to examine other stretching protocols with other muscular groups to clarify the debate over whether stretching affects athletic performance.

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