ACUTE EFFECT OF QUADRICEPS STRETCHING ON PERFORMANCE AND MOVEMENT TECHNIQUE DURING SQUAT JUMPS

Cynthia Fantini; Hans-Joachim Menzel; Mauro Chagas

Biomechanics Laboratory (BIOLAB) – Federal University of Minas Gerais, Belo Horizonte, Brazil

The aim of this study was to analyze the acute effects of stretching on jumping performance (vertical velocity of the center of mass), vertical ground reaction force (peak force, rate of force development and impulse) and movement technique (joint angles and angular velocities) during the squat jump (SJ). Thirty male individuals performed the SJ test before and after one quadriceps stretching session. This session consisted of four 20-second repetitions of passive static stretching of quadriceps. The results indicated no significant difference in the performance, vertical ground reaction force or movement technique.

KEY WORDS: stretching, performance, squat jump.

INTRODUCTION:

Flexibility training is often prescribed before physical activities, although research has already been shown that maximal strength can decrease right after a stretching session, suggesting that stretching routines prior to exercise or athletic events are detrimental to performance. Changes in muscle stiffness and neural activation are pointed out as the mechanisms associated with the reduction of strength (Fowles, Sale & MacDougall, 2000), as the miogenic changes are more important than the neural ones (Weir, Tingley & Elder, 2005). However the configuration of the flexibility training load used in these studies is characterized as prolonged stretching protocols and not representative of commonly employed stretching routines. Additionally, the studies that showed a reduction of maximal strength after stretching used single joint isometric (Fowles, Sale & MacDougall, 2000; Weir, Tingley & Elder, 2005) and concentric tests (Nelson & Kokkonen, 2001), which are not specific to evaluate the performance in multiple dynamic joint activities. McBride, Deane & Nimphius (2005) and Power et al. (2004) observed a reduction of maximal isometric force output in single joint tasks, but did not find changes in performance during multiple joint tasks. Studies that analyzed the acute effect of stretching on multiple joint dynamic activities, such as vertical jumps, have presented divergent results (Church et al., 2001; Young & Elliott, 2001; Power et al., 2004; Unick et al., 2005). The aim of this study was to analyze the acute effect of quadriceps passive static stretching on ground reaction force, movement technique and performance during squat jumps (SJ).

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 two jumps using the SJ technique in two different sessions: before and after a quadriceps stretching program (experimental protocol) and before and after a 20 minutes rest period (control protocol). The experimental and control protocols were interspersed with a 24 hours rest period and the order was randomized. Five sessions of SJ training were performed two weeks prior to the data collection in order to familiarize the volunteers to this jump technique.

Data collection :

Kinetic Data: The vertical ground reaction force was measured using a force platform, model AMTI OR6-7, with acquisition frequency of 1KHz. The force-time (F-t) curve was recorded with SIMI Motion 7.2 software and analyzed using DasyLab 4.0 software. The A/D converter used was the Data Translation DT9800-EC. The parameters peak of force (PF) and rate of force development (RFD) were extracted from the F-t curve. The RFD was defined as the greatest amplitude of the first differential of the F-t signal (Sale, 1991). The vertical velocity of the center of gravity (Vcg) was defined from the impulse (I) obtained from the F–t curve. The SJ performance was characterized by the parameter Vcg.

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 SIMI Motion 7.2 software. 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, knee and hip angles at the initial position (φ_0A, φ_0K, φ_0H), at the moment in that the peak of force is reached (φ_{PF}A, φ_{PF}K , φ_{PF}H) and the maximal ankle and knee angular velocities during the push-off phase (ω_{max}A, ω_{max}K). 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.

Fig.1A

Fig.1B

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

The stretching exercise was made using the QSB and the positioning was the same adopted during the flexibility measurement. The passive static stretching session consisted of four sets of 20 seconds with 20-second rest interval between each set.

Statistical Analysis: Because this was a within-subject study design, group data was compared between pre and post intervention for each protocol (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 flexibility training resulted in a significant gain score of approximately 6º in the active knee flexion ROM for experimental protocol (pre-test = 31,8º ± 10,1; post-test = 37,7º ± 9,5). The descriptive statistics of the examined variables in both protocols (means ± SD) are presented in table 1.

Table 1 Values (Means±SD) of the different parameters for experimental and control protocols.

	experimental		control	
Parameters	Pre	post	pre	post
Vcg (m.s^{-1})	2.32 ± 0.16	2.29 ± 0.18	2.29 ± 0.25	2.31 ± 0.21
I (N.s)	170.6 ± 22.0	168.0 ± 21.7	169.4 ± 22.7	170.4 ± 22.8
PF (N)	928.2 ± 128.7	917.0 ± 137.1	922.9 ± 122.2	931.9 ± 136.3
RFD (N.s^{-1})	6595.6 ± 1854.8	6327.6 ± 1805.1	6605.9 ± 1661.9	6479.5 ± 1990.5
φ_0A	92.7 ± 5.3	92.3 ± 5.2	92.1 ± 5.3	91.9 ± 5.3
φ_0K	88.8 ± 7.1	89.4 ± 7.1	88.7 ± 6.8	87.6 ± 9.0
φ_0H	68.5 ± 13.5	67.0 ± 12.9	68.4 ± 13.1	68.4 ± 13.9
Φ_{PF}A	98.9 ± 6.0	98.7 ± 4.9	98.2 ± 4.8	98.1 ± 5.2
Φ_{PF}K	113.4 ± 7.9	115.4 ± 7.1	114.0 ± 7.1	115.3 ± 8.1
Φ_{PF}H	115.0 ± 13,6	118,6 ± 7.5	116.9 ± 7.9	119.0 ± 10.1
ω_{max}A	549.5 ± 42.0	553.4 ± 48.0	557.8 ± 35.8	559.6 ± 46.1
ω_{max}K	622.9 ± 35.5	617.4 ± 44.0	629.6 ± 35.3	623.2 ± 41.1

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

DISCUSSION:

The stretching training load produced a gain of 6º on the knee flexion range of motion (ROM), indicating possible changes in the passive resistance. This change on the ROM was not enough to influence the performance during the SJ, which is determined from the vertical velocity of center of gravity. This jump technique is characterized by a concentric muscle action. A reduction in the concentric force was reported for the knee flexors and extensors after a stretching session (Nelson & Kokkonen, 2001). The present study did not verify any change in the force related parameters (peak of force and rate of force development). The highest flexibility training load applied by Nelson & Kokkonen (2001) could be responsible for the strength reduction. Additionally, these authors used a single joint concentric test to evaluate the muscular strength. As shown by McBride, Deane & Nimphius (2005), the same flexibility training load may produce a reduction of the maximal force output during single joint isometric tests without changes in multiple joint tests.

Because concentric muscle performance is positively correlated to the muscle tendon units' (MTU) stiffness (Wilson, Murphy & Pryor, 1994), a reduction in SJ performance after stretching could be expected. However this was not observed, in agreement with Young & Elliott (2001) and Power et al. (2004).

Young & Elliott (2001) did not report significant reductions in peak of force, rate of force development and jump height. These results were explained by the possible positive effect of the warm-up performed before the strength tests, which could minimize the disadvantage induced by the flexibility training. These arguments are not valid to the present study because warm-up routines were not used.

Power et al. (2004) used an increased flexibility load compared to the present study and observed reduction in maximal isometric force and reduction in the quadriceps muscular activation. However, these changes did not produce a reduction in SJ performance. That indicates that the persistent performance during the SJ is due to others mechanisms.

The kinematic analysis showed that at the moment of the peak of force during the push-off phase, the joint angles did not change significantly after stretching. That does not indicate that an alteration in the length-tension curve of the knee extensors had not occurred. Weir, Tingley & Elder (2005) observed changes in the length-tension curve of the plantar flexors after passive static stretching during a single joint isometric contraction. However, in complex dynamic actions, these changes could not induce differences to the overall force output due to a possible change in the activation of other muscular groups to compensate the shown force deficit presented by the stretched muscle group. Furthermore, the same joint positions reported in the present study from the kinematic analyses before and after the stretching do not ensure the same muscle and tendinous structure lengths, if analyzed separately. Finni *et al*. (2001) and Kurokawa, Fukunaga & Fukashiro (2001) used ultrasonography to analyze the behaviour of muscle fascicles and tendinous tissues from different muscles during the SJ. According to these authors, the behaviour of each one of these structures, separately, does not correspond to the behaviour of the entire muscle-tendon unit. Therefore the present study did not identify changes in the movement technique, however it is not possible to affirm that the behaviour of each structure and the interaction between fascicle and tendinous tissues did not alter.

CONCLUSIONS:

In summary, one session of stretching exercise did not alter the SJ performance, ground reaction force and the movement technique. Although some studies indicate an exclusion of stretching exercises before activities in which maximal strength is necessary, this decision seems to be premature concerning multiple joint movements. It is still necessary that other studies using the same methods are being made. The resulting effects of stretching several other muscular groups using the investigated variables still remain unknown.

REFERENCES:

Church, J. B., Wiggins, M. S., Moode, F. M. & Crist, R. (2001). Effect of warm-up and flexibility treatments on vertical jump performance. *Journal of Strength and Conditional Research*, **15**(3), 332-336.

Fowles, J. R., Sale, D. G. & MacDougall, J. D. (2000). Reduced strength after passive stretch of the human plantar flexors. *Journal of Applied Physiology,* **89**, 1179-1188.

Finni, T., Ikegawa, S., Lepola, V., & Komi, P. V. (2001). In vivo behavior of vastus lateralis muscle during dynamic performances. *European Journal of Sport Science,* **1**(1), 1-13.

Kurokawa, S., Fukunaga, T. & Fukashiro, S. (2001). Behavior of fascicles and tendinous structures of human gastrocnemius during vertical jumping. *Journal of Applied Physiology,* **90**, 1349-1358.

McBride, J. M., Deane, R., & Nimphius, S. (2005). Effect of stretching on agonist-antagonist muscle activity and muscle force output during single and multiple joint isometric contractions. *Scandinavian Journal of medicine and science in sports*, **0**(0).

Nelson, A. G. & Kokkonen, J. (2001). Acute ballistic muscle stretching inhibits maximal strength performance. *Research Quarterly for Exercise and Sport,* **72**(4), 415-419.

Power, K., Behm, D., Cahill, F., Carroll, M. & Young, W. (2004). An acute bout of static stretching: effects on force and jumping performance. *Medicine and Science in Sports and Exercise,* **36**(8), 1389-1396.

Sale, D. G. (1991). Testing strength and power. In: MacDougall, J.; Wenger, H.; and Green, H. (Ed.) *Physiological testing of the high-performance athlete.* Champaign: Human Kinetics, 21-106.

Unick, J., Kieffer, H. S., Cheesman, W. & Feeney, A. (2005). The acute effects of static and ballistic stretching on vertical jump performance in trained women. *Journal of Strength and Conditional Research,* **19**(1), 206-212.

Weir, D. E., Tingley, J. & Elder, G. C. B. (2005). Acute passive stretching alters the mechanical properties of human plantar flexors and the optimal angle for maximal voluntary contraction. *European Journal of Applied Physiology,* **93**, 614-623.

Wilson, G. J., Murphy, A. J. & Pryor, J. F. (1994). Musculotendinous stiffness: its relationship to eccentric, isometric, and concentric performance. *Journal of Applied Physiology*. **76**(6), 2714-2719.

Young, W. & Elliott, S. (2001). Acute effects of static stretching, proprioceptive neuromuscular facilitation stretching, and maximum voluntary contractions on explosive force production and jumping performance. *Research Quarterly for Exercise and Sport,* **72**(3), 273-279.