Apunts Med Esport. 2016;xxx(xx):xxx–xxx

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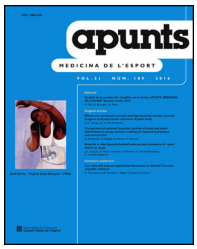

ORIGINAL ARTICLE

Vertical jump performance after passive static stretching of knee flexors muscles

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Received 1 March 2016; accepted 10 May 2016

KEYWORDS
Performance;
Vertical jump;
Stretching;
Hamstring

Abstract
Objective: The purpose of this study was to investigate the acute effects of passive static stretching (PSS) applied on hamstring muscles on vertical jump height (VJ) performance.
Materials and methods: Ten men and 10 women with previous experience in resistance training were volunteers, and performed two protocols on non-consecutive days: traditional protocol (TRAD) including VJ without previous PSS, and a PSS protocol, with VJ immediately after stretching.
Results: Significant differences were observed in VJ performance with PSS (53.6 ± 8.5 cm) when compared to TRAD (47.9 ± 13.1 cm) for the women's group ($p = 0.021$). Significant differences were also observed in the men's group with PSS (58.4 ± 12.3) versus TRAD (51.4 ± 9.6) protocol ($p = 0.001$).
Conclusion: These results suggest that PSS applied only on hamstring muscles may have an acute effect on increasing the VJ performance for both men and women with previous experience in resistance training.

PALABRAS CLAVE
Desempeño;
Salto vertical;
Estiramiento;
Isquiotibiales

Rendimiento en el salto vertical después del estiramiento pasivo de los músculos flexores de la rodilla

Resumen
Objetivo: El objetivo de este estudio fue investigar el efecto agudo del estiramiento estático pasivo (ESP) aplicado en los músculos flexores de la rodilla en el rendimiento del salto vertical (SV).

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http://dx.doi.org/10.1016/j.apunts.2016.05.005

Please cite this article in press as: de Souza LML, et al. Vertical jump performance after passive static stretching of knee flexors muscles. Apunts Med Esport. 2016. http://dx.doi.org/10.1016/j.apunts.2016.05.005

Material y métodos: El estudio consistió en 10 hombres y 10 mujeres voluntarios con experiencia previa en el entrenamiento de fuerza (EF). Los sujetos realizaron 2 protocolos: EF sin ESP (TRAD) y SV inmediatamente después del estiramiento (ESP).
Resultados: Hubo una diferencia significativa en el rendimiento del salto vertical ESP (53,6 ± 8,5 cm) en comparación con el TRAD (47,9 ± 13,1 cm) en el grupo femenino. En comparación con los hombres también hubo diferencias significativas en el ESP (58,4 ± 12,3) y el TRAD (51,4 ± 12,3) ($p < 0,05$).
Conclusiones: Este estudio sugiere que el estiramiento estático pasivo aplicado solo en los flexores de la rodilla puede mejorar el rendimiento durante el SV para los hombres y mujeres entrenados.

Introduction

Stretching exercises are commonly performed by apparently healthy people and athletes with the goal to increase or maintain joint range of motion, and improving athletic performance, respectively.[1,2] Moreover, it can be used as part of warming up exercise before sports activities[3] and rehabilitation programs.[4,5]

There are several types of flexibility training methods, such as the static stretching, which is used to reach the above-mentioned benefits.[3] Despite the advantages of stretching, there are several studies which have been indicated that performing stretching before resistance exercises can significantly reduce torque,[6,7] strength performance,[8,9] power output, and agility.[10]

Regardless the force production mechanism, muscle power is characterized by several tasks performed in sport fields. One of these movements commonly performed during sport training programs and muscle power assessment is the vertical jump (VJ). In relation to concurrent training between flexibility and muscle power, there is still no consensus about the effect of stretching before power training. Bradley et al.[11] observed a significant reduction in the VJ performance after passive static stretching (PSS) applied in quadriceps, hamstring, and ankle flexors muscles. However, Sandberg et al.[12] found significant improvement in the VJ performance after PSS applied in hip flexors and ankle dorsiflexors muscles when compared to a protocol without stretching. In addition, other studies have been noted that the chronic application of PSS does not seem to have a negative effect on VJ performance.[13,14]

Besides these controversial results, to date, there is a lack of evidences of the subsequent VJ performance followed by PSS only adopted for knee flexors (KF) muscles. The KF muscles have an important function during the VJ, because of it synergic role with the quadriceps and gastrocnemius muscles, which is considered responsible for improving the joint stabilization during knee flexion–extension, and also improving the elastic energy storage.[15] Additionally, KF plays an important role during jumping tasks in order to assists the anterior cruciate ligament stabilization and also avoid the anterior tibial displacement.[16]

Furthermore, evidences related with the potential effects of PSS implemented with the goal to improve the VJ performance, may help coaches and conditioning professionals during the prescription of power training for lower limb muscles. Therefore, the purpose of this study was to investigate the acute effect of PSS applied in KF muscles on the VJ performance of recreationally trained men and women. We hypotheses that lower volume of PSS applied in KF muscles may increasing the stretch-shortening cycle (i.e. elastic energy storage) during the eccentric phase, and consequently, improving the VJ performance.

Materials and methods

Participants

The study was comprised 10 male and 10 female volunteers with previous experience in resistance training. The follow inclusion criteria were adopted: (a) to practice resistance training (RT) for at least three years; (b) to perform jumping tasks and power training with a frequency of three times per week; (c) to perform stretching exercises at least three months. The exclusion criteria were: (a) to respond the PAR-Q questionnaire positively; (b) to present any previous osteomioarticular injuries or surgery in lower limb; (c) to use any ergogenic substance that could influence in the power performance.

All the participants signed a consent form and the study was duly approved by the Castelo Branco University Research Ethics Committee under No. 2012/056 protocol and it was in according to the guidelines of the National Health Council Resolution 466/12 of human experiments. The anthropometric measures (i.e., height and body mass) were measured on a digital scale Filizola TM (Beyond Technology), following the recommendations proposed by the *International Society for the Advancement of Kinanthropometry* (ISAK).

Procedures

Before each test session, a standard warm up was adopted. The warm up was applied during 10 min and consisted of jogging, short sprints, and small jumps.[17]

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