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ACUTE EFFECT OF STATIC AND DYNAMIC STRETCHING ON TONE AND ELASTICITY OF HAMSTRING MUSCLES AND ON VERTICAL JUMP PERFORMANCE IN TRACK-AND-FIELD ATHLETES

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ABSTRACT

The aim of the study was to evaluate and compare acute effect of static and dynamic stretching exercise on hamstring muscles tone and jump performance in trained track-and-field athletes. Twelve male track-and-field elite athletes (mean age: 22.0±2.1 years) who trained speed and explosive power (sprint, jumps and decathlon) voluntarily joined in the study. Muscle tone and elasticity characteristics (frequency and logarithmic decrement, respectively) of hamstring muscles (biceps femoris and semitendinosus) were measured by Myoton PROdevice (Myoton Ltd, Estonia). Squat jump height was measured by telemetric system BTS G-studio (BTS S.p.A., Italy). All characteristics were measured before and after stretching exercise. Frequency of hamstring muscles did not differ significantly after static and dynamic stretching. Hamstring muscle' decrement decreased by 2.9% ($p<0.01$) after static stretching. Jump height increase by 7.1% ($p<0.01$) after dynamic stretching and decrease by 5.2% ($p<0.05$) after static stretching was noted. Muscle tone and elasticity characteristics did not correlate with jump height. This study shows that dynamic stretching has a positive effect on explosive power in trained track-and-field athletes and it is preferable to use static stretching after warm-up of these athletes.

Keywords: *dynamic stretching, static stretching, muscle tension, squat jump*

INTRODUCTION

Stretching exercise is a part of warm-up in many sport activities. Athletes use stretching exercise to maximize result, prevent injuries and increase joint mobility [22, 34]. Many studies have shown negative effect of static stretching (SS) on muscle performance by reducing muscle strength [5, 19, 25]. Acute SS reduces vertical jump performance [12–14, 23, 29, 30]. However, Wong et al. [38] study did not find any negative effect of SS on performance if SS was done before dynamic stretching (DS). The study also suggested that there was no difference between 30-s, 60-s and 90-s of total SS duration.

Previously it was demonstrated that DS influences positively on explosive performance [26, 39]. Acute DS improves vertical jump result [24, 28, 39]. However, other studies [16, 33] reported no effect of vertical jump height. Samson et al. [32] and Bishop and Middleton [8] in their research did not find any difference between SS and DS. Results of studies are contradictory, because there are many different aspects what can affect results. Important aspects are type of stretching exercise [27] and number of exercise [2, 3]. Stretching intensity, the duration of exercise and affected muscle group are factors that influence performance [6, 41]. Some studies suggested that less than maximal intensity stretching might not produce stretch-induced deficits. In a study of Avela et al. [2] it was demonstrated that 2 min of SS at the 90% intensity had no effect on concentric calf raise and drop jump height.

Muscle tone is defined as stiffness or passive resistance of the pressure [35]. Enoka [17] defines muscle tone as muscle ability to resist the movement of joints. Muscle tonede pends on two major physiological factors – viscoelastic properties of soft tissue and muscle contractile ability [35]. Muscle compliance can be measured directly or indirectly. MyotonPRO is one of the newest devices to determine muscle tone directly. Device has a probe what exerts a brief (15 m/s) mechanical impulse at pre-determined force (0.4 N) followed by quick release. Natural oscillation of muscle and logarithmic decrement of dampening oscillations as well as other characteristics are calculated from acceleration graph [4]. The device can be used reliably by different users to assess muscle parameters in healthy people of different ages [1]. To our knowledge no research published where effect of SS exercise as compared to DS exercise in association of muscle tone characteristics would studied in highly trained athletes.

The aim of the study was to evaluate and compare acute effect of static and dynamic stretching exercise on hamstring muscles tone, elasticity and vertical jump performance in speed and explosive power trained male track-and-field athletes.

MATERIALIS AND METHODS

Subjects

Twelve male track-and-field elite athletes (age: 22.0±2.1 yrs, body weight 79.5±7.0 kg, height 183.8±6.4 cm) participated in the present study. Subjects were ranked at Estonian Athletic Association and trained speed and explosive power (sprints, jump and decathlon). Their training load was 12–15 h per week and exercise period 10.8±3.3 yrs. The participants had not experienced any injury to the lower limbs in the 12 months before the study and were able to perform squat jump, static and DS exercises without feeling any undue discomfort. The subjects were at rest from any strong training or other physical activity in the three days before the study. Exclusion criteria were recent injuries that could affect their jump's ability. Before the study all participants completed a pre-test medical questionnaire and gave written informed consent. All the experimental procedures were approved Ethical Committee of the University of Tartu.

Methods

Anthropometric measurements

Body weight was measured with a scale to the nearest 0.1 kg (Circle Balance, Soehnle Germany) and body height with an anthropometer (Soehnle Professional, Germany).

Warm up

Warm up procedure consisted of a 10 minutes run on a motorized treadmill (mod. OMA-116B, Oma Metal Industrial Co. Ltd, China) at heart rate between 130–140 bpm (monitored by Polar RS300X, Polar Electro, Finland). Warm-up and all measurements were performed in room temperature of 22–23° by Celsius.

Static stretching of hamstring muscle

The static stretching exercise is shown on Figure 1. In static stretching routine, the subjects asked to lie down and pull leg (bent at the knee 120°) towards to chest, other leg was full soleplate on the floor (bent at the knee 90°). The intensity of stretching was 75% of maximal, measured with the Borg Scale of Perceived Exertion [20]. Exercise was made three times in 3 series with duration of 20 s for both legs. Total duration was 60 s between every set. An athlete had 30-s pause to rest, sitting on the chair with back supported.

Figure 1. Static stretching exercise.

Dynamic stretching of hamstring muscle

Dynamic stretching exercise is shown on Figure 2. In dynamic stretchin subject was standing next to the wall and flourish leg front and back at the frequency of 60 bpm controlled by electrical metronome. Knee was flexed at the knee to provide hamstring stretching. Exercise was made three times in 3 sets with duration of 20 s for both legs. Between every set 30-s rest period was allowed.

A **B** **C**

Figure 2. Dynamic stretching exercise. A – initial position; B – leg forward, C – leg backward.

Measurements of muscle functional characteristics

Muscle tone and elasticity characteristics were measured using a hand-held MyotonPRO device (MyotonPRO, Myoton Ltd, Estonia) [9, 36, 37]. Hamstring muscles (biceps femoris and semitendinosus) were tested bilaterally in the middle point of muscle belly symmetricaly for right and left body side. The muscle tone and elasticity characteristics were evaluated with the muscles completely relaxed and the subjects lying prone on a massage table (Fig. 3). Following characteristics of muscle tone are calculated by software of MyotonPRO [36, 37]: (1) frequency of natural oscillation (Fr, Hz), the frequency of damped mechanical oscillation of muscle tissue, is an index of the tension in the muscle; (2) logarithmic decrement of oscillations amplitude damping (D), characterisics of elasticity or the ability of muscle to restore its initial shape after contraction. A lower level of decrement reveals a better muscle elasticity and ability of contraction; (3) dynamic stiffness of the muscle (St; N/m) or the ability of tissue to restore it shape after removing of external force acting on the muscle; (4) mechanical stress relaxation time (Rt, ms) and (5) the gradual elongation of a muscle over time (C, creep or Deborah number) when placed under a costant tensile stress. The characterstics of muscle tone (frequency) and elasticity (decrement) are analysed in this article. For this study, a MultiScan pattern of ten measurements was used and the mean was considered. Pooled data for right and left body side were calculated.

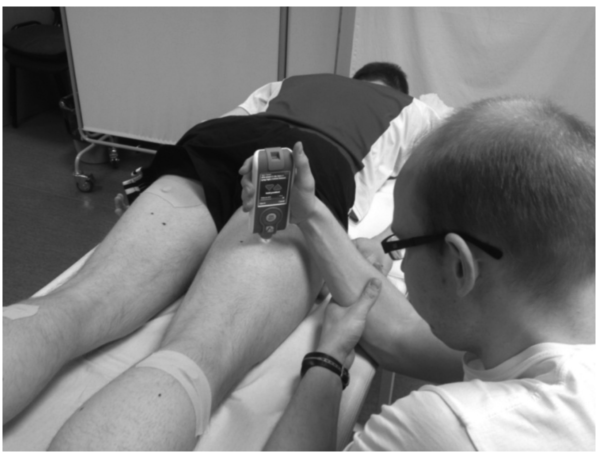

Figure 3. Measuring of muscle tone in hamstring muscles by hand-held MyotonPRO device (Myoton Ltd, Estonia).

Vertical jump height measurement

Vertical jump characteristics were investigated by telemetric system BTS G-studio with an accelerometer G-sensor (BTS S.p.A, Italy). This sensor is inserted in the specific pocket of the belt and positioned on level of the 5th lumbar vertebrae. To assess the explosive force of leg extensor muscles all athletes performed squat jump (SJ) at maximal intensity [10]. SJ was performed two times for each session of jump test with 45 s rest between each jump, sitting on the chair. The best jump result was accepted for future analysis.

Study design

Before the study participants were informed about the purposes of the study and were taught how to perform stretching exercises and had possibility to perform SJ.

SS and DS tests were performed in two different days with the same procedure. In the first day of the study the anthropometric parameters were measured and the DS was performed. In the second day SS was performed at the same hour of the first testing. On both days muscle tone and elasticity characteristics of hamstring muscle and SJ height were measured after warm-up, before and after stretching.

Statistical analysis

Data are presented as mean values and standard deviation (±SD). Student T-test with repeated measures was performed to compare the results of jump test and pooled muscle tone and elasticity characteristics before and after static and dynamic stretching. Lowest statistical significance level was set at $p<0.05$. Pearson correlation was calculated between muscle tone and elasticity characteristics and jumps height with the software MS Excel 2007.

RESULTS

Muscle tone and elasticity characteristics

The results of muscle tone and elasticity characteristics before and after static and dynamic stretching are presented in Table 1.

Table 1. Pooled characteristics of hamstring muscle (frequency of natural muscle oscillation) and elasticity (characteristics of logarithmic decrement of natural muscle oscillation) before and after static and dynamic stretching exercises in speed and explosive power trained track-and-field male athletes (n=12) (mean ± SD).

Parameters	DYNAMIC STRETCHING		STATIC STRETCHING	
	Before	After	Before	After
Frequency (Hz)				
BF	16.4±1.2	16.4±1.1	16.6±1.0	16.7±1.1
ST	17.3±1.3	17.4±1.6	17.5±1.4	17.5±1.3
Decrement				
BF	1.39±0.17	1.39±0.18	1.37±0.15	1.40±0.17*
ST	1.37±0.14	1.37±0.17	1.34±0.13	1.38±0.15**

Note: BF – biceps femoris muscle, ST – semitendinosus muscle. * p<0.05; ** p<0.01, as compared before and after static stretching.

No significant difference between semitendinosus and biceps *femoris m*uscle in frequency and decrement before and after DS measurements was found. Increase of decrement of biceps *femoris* muscle by 2.2% (p<0.05) and of semitendinosus muscle by 2.9% (p<0.01) after SS was noted. Frequency of biceps *femoris* and semitendinosus muscle did no change significantly after SS.

Squat jump

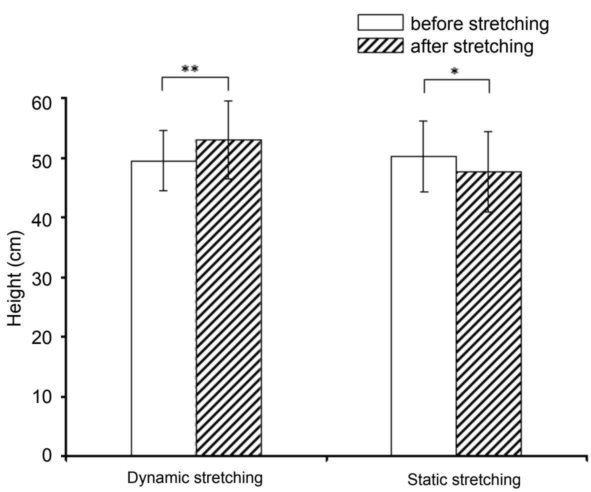

Figure 4. Squat jump height (cm) changes before and after static and dynamic stretching exercise in speed and explosive power trained male track-and-field athletes (n=12) (mean ± SD). * p<0.05; ** p<0.01.

Squat jump results are presented in Figure 4. Decrease of SJ height by 5.2% ($p<0.05$) after SS was noted. Athletes had increase of squat jump height by 7.1% ($p<0.01$) after DS compared to before stretching.

DISCUSSION

In this study the acute effect of static and dynamic stretching exercise on hamstring muscles tone characteristics and vertical jump performance in speed and explosive power trained track-and-field athletes was evaluated and compared. The correlation between measured characteristics was analysed. The main findings of this study are: (1) after static and dynamic stretching frequency of hamstring muscles did not change significantly; (2) after static stretching elasticity characteristics (decrement) significantly increased (elasticity worsened) and after dynamic stretching decrement did not change in both measured hamstring muscles in comparing to before and after stretching results; (3) the decline in squat jump performance after static stretching and it increase after dynamic stretching was noted.

In the present study no difference of frequency before and after SS and DS exercises between semitendinosus and biceps femoris muscle was spotted. It was found only one study which examined stretching effect on muscle tone characteristics [31]. Thirty physically active men (23.2±3.2 yrs old) performed static stretching exercise for hamstring muscle three times in 3 sets with duration of 30 s for both body sides. Muscle tone, elasticity and stiffness characteristics were measured using Myoton-3 device. Authors also did not find any change in biceps *femoris* frequency. There was no change in decrement of hamstring muscle after static stretching and this result differs from our study. It can be explain by different stretching exercises and also by difference of duration of exercises. Subjects of their study were not highly trained athletes, too, as compared to the present study and it can affect results. Ylinen et al. [40] did not find significant impact of static stretching on hamstring muscle frequency. They used long term passive static stretching (straight leg raise, using special device for exercise) during four week where every day was performed six repetitions each lasting 30 s with 30 s intervals. Subject were 30 none active men (mean age ±SD; 34±10 year). It shows that static stretching did not affect muscle frequency.

Results of the present study showed that static stretching have negative effect on muscle elasticity (increase of decrement). After static stretching hamstring muscles change more plastic. Static exercise had more influenced on decrement of semitendinosus as compared to biceps *femoris* muscle. Changes in the elasticity can be justified that actin- and myosin chain optimal distance is disturbed, it is caused by static stretching. If muscle is stretched out then ability to generate force is dropped [19].

Present study demonstrated a decrease in squat jump performance after static stretching and it increase after dynamic stretching. These results are in line with other research reported SS negative effect on jump performance [18, 29]. Other studies show an improvement in squat jump performance after dynamic stretching [11, 15]. Possible mechanisms in performance enhancement include augmentation of nervous system activation improved the sensitivity of nerve receptors and increasing in speed of nerve impulse, and postactivation potentiation. Increased blood stream during exercise can also affect jump results [7, 21]. Muscle tone and elasticity characteristics did not correlate significantly with jump height. However, the results obtained in this study reveal that static stretching has a negative influence on mechanical properties of muscles. After static stretching muscle elasticity worsened and this factor can cause jump height decrease.

A major limitation of our study is the relatively small number of subjects even if the cohort under study was very homogeneous. Future studies could be performed with bigger list of stretching exercises and which are more sport specific in athlete natural environment.

It is concluded that no difference in tone characteristics of semitendinosus and biceps femoris muscle before and after SS and DS was noted as compared to before exercises. Decrement of hamstring muscles increased after SS exercises did not change after DS.The squat jump performance decline after SS and increase after DS was noted in speed and explosive power trained male track-and-field athletes. This study shows that dynamic stretching has a positive effect on explosive power in trained track-and-field athletes and it is preferable to use static stretching after warm-up of these athletes.

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