Immediate Effect of Vibrating Foam Roller on the EMG Amplitude of Muscle Hamstring of Healthy Subject with Hamstring Tightness

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Abstract

Hamstring tightness is the reduction of the hamstring muscle's ability to lengthen from a neutral position accompanied by a feeling of limitation or discomfort in the posterior thigh. Shortening of the hamstring can cause misalignment of the trunks, reduce neuromuscular efficiency, increase energy expenditure, and excessive strain to the knee joint. Foam rolling can improve joint range of motion, neuromuscular function, reduce muscle and myofascial pain and regulate muscle tone. The aim of this study was to assess the immediate effect of vibrating foam roller on the hamstring muscle's EMG amplitude in healthy subjects with hamstring tightness. The subjects of this study were 14 healthy males age 20-45 years, with hamstring tightness (KEA >20°). They divided into 2 groups, the Vibrating Foam Roller (VFR) group and the Non-Vibrating Foam Roller (NVFR) group. The outcome measured is the amplitude of maximum isometric contraction of Biceps femoris (BF) and Semitendinosus (ST) in knee flexion angle 30 and 90 recorded by surface EMG. The VFR group showed increase of BF30 197,23+26,27 (p value = 0,016) BF90 174,26+46,72 (P value= 0,033) and ST90 197,48+18,36 (p value=0,005). NVFR group showed decrease of BF30 130,9+24,18 (p value = 0,07) BF90 116,09+33,71 ST30 144,63+28,67 (p value 0,685) and ST90 155,63+53,07 (p value 0,526). The Δ amplitude EMG results between the two groups were significant difference in BF30 (p value = 0,002) and BF90 (p value = 0,001). This study concluded that vibrating foam roller significantly increased the hamstring muscle's EMG amplitude.

Keywords: *foam rolling; hamstring tightness; vibrating foam roller, surface electromyography.*

Introduction

Hamstring tightness is the reduction of the hamstring muscle's ability to lengthen from a neutral position accompanied by a feeling of limitation or discomfort in the posterior thigh[1]. Hamstring tightness often occurs due to the adaptive shortening of muscle structures, especially the myofascial tissue. Knee Extension Angle (KEA) is one of standard measurement of hamstring tightness. The patient is in supine position, the hip is flexed 90° and the knee was moved into full extension until he feels discomfort in his posterior thigh. The KEA is the degree of knee of knee flexion in terminal extension. KEA more than 20° shows hamstring tightness[2].

Individuals who work while sitting for 6-8 hours per day have a risk of experiencing hamstring tightness with a prevalence of 85.7%[3]. A study by Naqvi et al. (2017) on healthy students found 35% of subjects had hamstring tightness[4]. Kanishka et al. (2019) found a prevalence of hamstring tightness in sewing machine operators of 83.4%, with 40% of them having symptoms of low back pain[5].

Shortening of the hamstring muscles can cause misalignment of the trunks, reduce neuromuscular efficiency, increase energy expenditure and give excessive strain to the knee joint[6]. In athletes' populations, limitation of hamstring flexibility can produce musculoskeletal symptoms such as reduced strength, stability and muscle endurance. This will increase the risk of repetitive injuries, decrease athletic performance, and affect the psychosocial aspects of athletes[7].

The use of foam roller to relax myofascial tissue and by that, increasing muscle flexibility is currently emerging because it is easy, economical and can be done independently[8]. Foam rolling application can improve joint range of motion, neuromuscular function, reduce muscle and myofascial pain and regulate muscle tone. The mechanism of action of a foam roller occurs due to changes in muscle, myofascial tissue and stimulation of mechanical receptors[9]. The use of foam rollers in combination with vibrations has only recently begun to be commercialized. A better range of motion of the knee joint was reported after application of a vibrating foam roller to the knee flexor muscles compared to using a regular foam roller [10,11]. The supplemented vibration can put an excessive load on the joint, and when the vibration is given it will cause co-contraction of the agonist and antagonist muscles acting on the joint[12]. There are few studies on the effect of vibrating foam roller application on muscle performance and activation using EMG. Based on the description above, the aim of this study was to assess the immediate effect of vibrating foam roller applications on the hamstring muscle activation of healthy subjects by measuring the EMG amplitude.

Methods

This study was an experimental study in healthy male subjects with randomized pre-test and post-test group design. The study subjects were 14 healthy men who met the inclusion criteria. The inclusion criteria were healthy men, ages 20-45 years, body mass index (BMI) 18.5-24.9 kg/m2, Knee Extension Angle >20°, and has the willingness to participate in this study. Exclusion criteria were: 1) Fracture, pain, or impaired sensibility at lower extremities, 2) fracture, pain, muscle strength disorders in the upper extremities, 3) contractures at the lower extremity to be tested, 4) History or risk of deep vein thrombosis, 5) Peripheral artery disease of the lower limb, 6) malignancy and tumors, 7) Connective tissue disease, 8) Joint hypermobility and 9) Open wound or inflammation in the area of application. The subjects were randomly divided into two groups, the intervention group using VFR (n = 7) and the control group using NVFR (n = 7). Baseline data were collected before the application of foam rolling. The amplitude of hamstring muscle was recorded by surface EMG and measured maximum voluntary isometric contraction of Biceps femoris (BF) and Semitendinosus (ST) in knee flexion angle 30 and 90 before and after rolling. All participants were given instructions about the objectives and procedures of the study and invited to participate after signing the informed consent form.

The data were analyzed using the Statistical Package for Social Sciences (SPSS version 23). Data normality assumptions were used the Shapiro Wilk test. The baseline characteristics between intervention and control groups were compared using an independent sample t-test. The differences between EMG amplitude of hamstring muscles before and after the foam rolling in the VFR and NVFR group were analyzed using paired t-test. Between-group differences (delta) EMG amplitude of hamstring muscles were compared using independent t-tests. The differences were considered statistically significant at $p<0.05$.

Results and Discussion

Total subjects of this study were 14 participants who were divided into VFR and NVFR groups (7 participants in each group). None of the subjects reported any adverse effects during the foam rolling application. The baseline characteristics of the subjects such as age, weight, height, BMI, KEA value before application of foam rolling did not show a significant difference between the two groups (Table 1). There was statistically significant increase in BF30 ($p<0,05$) and BF 90 ($p<0,05$) in VFR group while in NVFR group there was a statistically significant decrease in BF 90 ($p<0.05$) (Table 2). There was statistically significant increase in ST 90 ($p <0,05$) but not in ST 30 ($p> 0,05$) in VFR group. NVFR group showed decrease of amplitude in ST 30 and 90 but it was not statistically significant ($p>0.05$) (Table 3). Comparison of the Δ EMG amplitude revealed that there was statistically significant difference between the two groups ($p>0.05$) in BF 30 dan BF 90 (Table 4).

Table 1. Baseline Characteristic of Subjects.

Variables	VFR Groups (n=7)	NVFR groups (n=7)	*p-value*
Age (years)	32.57±3.99	33.14±3.71	0.786*
Weight (kg)	67.43±8.54	67.28±9.26	0.761*
Height (m)	1.72±0.07	1.70±0.06	0.977*
BMI (kg/m^2)	22.74±1.21	22.99±1.87	0.766*
KEA pre-Rolling (°)	31.14±4.91	27.14±3.38	0.102*

* Saphiro-Wilk Test show normal distribution if p > 0,05

Tabel 2. sEMG Amplitude of The Biceps Femoris Muscle Before and After Foam Rolling Application

VFR (n=7)				NVFR (n=7)		
	before	**after**	***p-value***	**before**	**after**	**p-value**
30°	155.28±17.41	197.23±26.27	0.016*	142.39±27.82	130.9±24.18	0.07
90°	141.14±20.89	174.26±46.72	0.033*	145.62± 24.28	116.09±33.71	0.010*

*paired t-test, *s*ignificant if p value <0.05

Tabel 3. sEMG Amplitude of The Semitendinosus Muscle Before and After Foam Rolling Application

	VFR (n=7)			**NVFR (n=7)**		
	Before	**after**	**p-value**	**before**	**after**	**p-value**
30°	144.95+39.83	161.43+36.11	0.266	148.40+17.24	144.63+28.67	0.685
90°	170.34+11.40	197.48+18.36	0.005*	168.50+7.28	155.63+53.07	0.526

*paired t-test, significant if p value <0.05

Tabel 4. Comparison of Δ sEMG amplitude Before and After Exercise between Two Groups.

		Δ EMG (μV)	
	VFR (n=7)	NVFR (n=7)	*p-value*
BF30°	41.95±33.53	-11.49 ± 13.79	0.002*
BF90°	33.15±31.85	-29.55±21.39	0.001*
ST30°	16.44±35.63	-3.77±23.42	0.234
ST90°	27.14±16.80	-12.86±50.58	0.07

*Independent t-test, significant if p value <0.05

To our knowledge, no studies have been conducted to evaluate the effect of vibrating foam roller to EMG amplitude of hamstring muscle in healthy subject with hamstring tightness. The electrophysiological activation of the muscles initiates the production of mechanical force and can be observed through surface electromyography (sEMG) and indicates the degree of activation. The higher the EMG value, the higher the force generated by the muscle. The relationship between sEMG-force can be influenced by changes in the activation pattern of the motor unit, the anatomical, mechanical and electrical properties of the muscles, the relative location of the EMG electrode in the muscle and the nature of the contraction filament in the cell[13].

In hamstring tightness condition, there is decrease of ground substance of hamstring myofascial tissue, therefore reduce the water content of the tissue resulting in decrease its extensibility[14]. Zugel et al (2018) stated that the mechanical properties of fascial tissue are generally influenced by several factors, namely age, hydration conditions, molecular cross-link organization, and myofibroblast cell contractility activity[15]. Decrease of extensibility makes contraction of the muscle not optimal and increasing risk of musculoskeletal injury.

Foam rolling (FR) is a form of self-massaging in which the target muscles get rolling and compression movements using a foam roller device[16]. The purpose is to increase myofascial compliance and optimize the length-tension relationship[17,18]. Several proposed physiological and mechanical effects of using foam rollers as myofascial release are: change of fascia from a solid gel-like state to a more fluid 'sol' state due to heat or mechanical stress; namely thixotropy. SMR can increase tissue temperature, reducing fascial adhesion, and changing the viscoelastic and thixotropic properties of the fascia[13]. Mechanical stimulation that is applied to the tissue stimulates mechanical receptors that affect the proprioceptive input sent to the central nervous system. This in turn changes the corresponding motor unit tonus regulations with fascia[9]. Peacock et al (2014) stated that SMR can increase muscle work production by stimulating the nervous system to increase firing rate and muscle recruitment patterns[16].

The effect of myofascial release on the stimulation of the interstitial receptor tissue and Ruffini's nerve endings affects the autonomic nervous system, and lead to decreased sympathetic tone and changes which is beneficial on fascial and arteriolar capillary pressures. This will result in decreased myofascial tone and improved arterial function[16].

Fascial stiffness is largely determined by water content. When experiencing compression, there is a shift in fluid within the fascia. This may suggest that compression applied during the SMR can increase fascial compliance and ultimately increase tissue movement and mobilization [19].

The pressure applied to the fascia is thought to create an intrafascial electric charge, which stimulates the fibroblasts and fibroclasts in the tissue to create and digest collagen fibers resulting in fascial remodeling[20].

In the presence of muscles or tendons, the application of vibration can induce a tonic vibration reflex[21]. Tonic vibration reflex is the increasing of muscle contraction after activation of the proprioceptive system sensors arising from excitation of afferents Ia from neuromuscular spindles. This signal will activate α-motor neurons and will increasing recruitment of previously inactive muscle fibers. Vibration stimulus also affects the Golgi Tendon Organ (GTO) which will cause variations in muscle tension. Vibration stimuli also increase coactivation of the agonist-antagonists which will increase the force of contraction on the stimulated muscles and muscles which are synergistically connected. Vibration stimulus can stimulate the spinal and supraspinal areas resulting in more nerve control for better muscle fiber recruitment[22].

The EMG amplitude measurement results of the biceps femoris muscle before and after foam rolling application for 5 sets of 1 minute rolling and 30 second rest showed a significant increase in amplitude in the VFR group at an angle of 30° (p-value 0,016) and 90° (p-value 0,033). Whereas in the NVFR group, a significant difference occurred in the form of a decrease in the EMG amplitude found at an angle of 90° (p-value 0,010). EMG amplitude values of semitendinosus muscles before and after foam rolling application for 5 sets of 1 minutes rolling and 30 second rest showed significant differences in the VFR group at an angle of 90° (p-value 0.005). Significant differences were found in the **Δ** EMG amplitude of the biceps femoris muscle after 5 sets of 1 minute rolling and 30 second rest between the two groups at an angle of 30° (p-value 0.002) and 90° (p-value 0,001) There was no significant difference in the **Δ** EMG amplitude before and after 5 sets of 1 minute rolling and 30 second rest on the semitendinosus muscles between the two groups.

The study of Lim et al (2019) who reported application of foam rolling to the hamstring muscles for 5 minutes (1 minute rolling, 30 sec rest) resulted in an increase in% MVIC of vastus lateralis, vastus medialis, and rectus femoris muscles which is the antagonist of hamstring muscle in the VFR group. Whereas in the NVFR group, an increase in% MVIC was only found in the rectus femoris muscle. Comparison between groups showed that the difference in% MVIC was only found in the VL group and the rectus femoris[6].

Conclusion

In summary, application of the Vibrating Foam Roller to the hamstring muscles for 1 minute, 30 seconds of rest for 5 sets caused an increase in the sEMG amplitude of the hamstring muscles of healthy subjects with hamstring tightness. There was an increase in the sEMG amplitude of the lateral hamstring muscle (biceps femoris) which was higher in the vibrating foam roller group compared to the non-vibrating foam roller.

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