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EFFECT OF KINESIOTAPING INTERVENTION ON KNEE MUSCLE STRENGTH AND DELAYED ONSET MUSCLE SORENESS PAIN FOLLOWING ECCENTRIC FATIGUE TRAINING

RESEARCH ARTICLE

ABSTRACT

Purpose: This study aimed to investigate whether Kinesiotaping caused changes in pain and muscle strength over time in delayed onset muscle soreness (DOMS) following eccentric fatigue training.

Methods: Thirty-one healthy females with DOMS induced through eccentric fatigue exercise were randomly assigned to Group 1 (Kinesiotaping, n = 16) and Group II (control, n=15). Kinesiotaping was applied on Rectus femoris and Hamstring muscles after eccentric fatigue training. Primary outcome variables included pain severity and isokinetic muscle strength, tested in four different measurement times; following the fatigue training, 1 hour later, on the 2nd day and on the 7th day.

Results: Kinesiotaping intervention following eccentric fatigue training demonstrated better results in terms of hamstring muscle strength on the 2nd day ($p<0.05$). Pain severity started to increase in the 1st hour, and reached to the highest value 48 hours after DOMS induction. Pain severity significantly decreased in the 2nd and 7th days, approaching to the 1st hour value, in favor of Group 1 ($p<0.05$). There was no significant difference between groups in terms of pain levels and Rectus femoris and Hamstring muscle strengths, when measured just after eccentric fatigue training and the following 1st hour ($p>0.05$).

Conclusion: Results of the study indicated that Kinesiotaping intervention following eccentric fatigue training reduced DOMS pain on the 2nd and 7th days, and was effective in improving Hamstring muscle performance.

Key words: Pain; muscles; exercise.

KİNEZYOBANTLAMA UYGULAMASININ EKSENTRİK YORGUNLUK EĞİTİMİ SONRASI DİZ KAS KUVVETİ VE GECİKMİŞ KAS AĞRISI ÜZERİNE ETKİNLİĞİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışma, eksentrik yorgunluk eğitimini takiben meydana gelen gecikmiş kas ağrısında (GKA) kinezyobantlama uygulamasının ağrı ve kas kuvveti üzerinde zamanla değişikliğe sebep olup olmadığını incelemeyi amaçlamıştır.

Yöntemler: Eksentrik yorgunluk eğitimi sonucu GKA'na maruz kalan 31 sağlıklı bayan randomize olarak Grup 1 (Kinezyobantlama yapılan, n= 16) ve Grup II (Kinezyobantlama yapılmayan, n=15) olmak üzere ikiye ayrıldı. Eksentrik yorgunluk eğitimi sonrası M. Rektus femoris ve Hamstring kasları üzerine kinezyobantlama uygulandı. Yorgunluk eğitiminden hemen sonra, 1 saat sonra 2. günde ve 7. günde olmak üzere 4 farklı durumda değerlendirilen izokinetik kas kuvveti ve ağrı şiddeti ölçümleri temel sonuç ölçekleriydi.

Sonuçlar: Eksentrik yorgunluk eğitimini takiben bantlama uygulaması hamstring kas kuvveti açısından 2. günde daha iyi sonuçlar vermiştir ($p<0.05$). Ağrı şiddeti eksentrik yorgunluk eğitiminden sonra ilk 1. saatte artmaya başlamış ve GKA oluşumunu takiben 48. saatte en yüksek seviyesine ulaşmıştır. Ağrı şiddeti, 2. günde ve 7. günde Grup 1 lehine ilk 1. saatteki değerlerine yaklaşarak istatistiksel olarak anlamlı derecede azalmıştır ($p<0.05$). Eksentrik yorgunluk eğitimini takiben ve 1 saat sonra ağrı şiddeti ile M.Rektus femoris ve hamstring kas kuvveti açısından gruplar arasında istatistiksel olarak anlamlı farklılık yoktu ($p>0.05$).

Tartışma: Çalışmanın sonuçları, eksentrik yorgunluk eğitimini takiben kinezyobantlama uygulamasının gecikmiş kas ağrısını 2. ve 7. günlerde belirgin derecede azalttığını ve hamstring kas performansının geliştirilmesinde etkili olduğunu göstermiştir.

Anahtar kelimeler: Ağrı; kaslar; egzersiz.

INTRODUCTION

Eccentric contraction controls muscles during movement of the body, by enabling the movement to decelerate, and also accumulates the elastic recoil energy of the muscle. During eccentric training, muscular movement acts like shock absorbent structures, the length of the muscle extends, and this extension causes a negative workload (1,2). While eccentric training improves the muscle strength, it causes damage in the skeletal muscle fibers (1,3-5). There are several theories that explain the exercise induced Delayed Onset Muscular Soreness (DOMS) mechanism. One theory states that lactic acid accumulation is responsible from muscle spasm is seen after eccentric muscle training especially in the weak muscle with perception of pain at delayed stage. Another theory suggests that connective tissue damage leads DOMS. Especially fast twitch fibers may demonstrate stretch-induced injury under high load tension and this will expose connective tissue damage and muscle soreness. These mechanisms may induct inflammatory cell infiltration and reaction in the tissue. Monocytes convert to macrophages and accumulate at the injury site and this reaction sensitizes the Type III and Type IV nerve endings in 24-48 hours (6). There are more reports that explain the reason behind the strength reduction and Delayed Onset Muscular Soreness (DOMS), which are related to acute inflammatory reaction in the muscles of especially sedentary individuals after eccentric training (4-8).

Numerous noninvasive methods have been used to reduce the DOMS after eccentric training and various treatment modalities such as cryotherapy, stretching, massage, ultrasound, transcutaneous electrical nerve stimulation (TENS), hyperbaric oxygen treatment, anti-inflammatory drugs, and nutritional supplements are used (1,4).

Kinesiotaping (KT) is an elastic therapeutic tape developed in the 70's by Dr. Kenso Kase for prevention and treatment of sports injuries. Several researches show that, KT improves blood and lymph flow, increases proprioception, helps to relieve pain, facilitates joint and muscle alignment, and enhances muscle function through activation of skin receptors (9-12).

Although several approaches have been used to alleviate the symptoms of DOMS, effect of Kineosiotaping has not been investigated yet. The purpose of this study was to investigate the effects of Kinesiotaping intervention on knee muscle strength and feeling of DOMS pain when applied after the eccentric fatigue training in healthy females. The hypothesis of the present study was that, thigh Kinesiotaping following eccentric fatigue training would have a positive effect on DOMS pain and muscle strength reduction over time.

MATERIALS AND METHODS

Thirty-four healthy female subjects, aged between 21 and 26 years, participated in this study. Subjects without a history of any injury or surgery of the lower extremities and muscle training for the dominant leg in the last six months were included in this study. All of the subjects were using right leg to kick the ball, so this was defined as the dominant leg. Three individuals were unable to complete the study. While one could not use her entire strength, the other two were excluded from the study since they removed their kinesiotapes. The data from dominant legs were obtained after exercise (1st test), 1 hour later (2nd test), on the second day (3rd test), and on the seventh day (4th test).

All subjects were randomly assigned to Group 1 (Kinesiotaping, n = 16) and Group II (control, n=15) with simple randomization via flipping a coin (13). This study was approved by Clinical Researches Ethics Board (GO 15/68). All participants were informed about the study, and asked to sign a consent form.

Procedure

Eccentric Fatigue Training: The Isomed 2000 (Multi-Joint-System D+ R Ferstl GmbH, Hemau, Germany) isokinetic system was used for the isokinetic eccentric-eccentric muscle fatigue training (1,14). Prior to fatigue training, subjects were taught eccentric-eccentric muscle training in an isokinetic system at 180°/sec for five times, in order to prevent eccentric inflammation. Eccentric Quadriceps femoris and Hamstring muscle training was applied between 10° and 85° of knee joint of motion Eccentric isokinetic training for both

Table 1. Demographic characteristics of the subjects.

	Group 1 (n=16) Mean±SD	Group 2 (n=15) Mean±SD	
Age (years)	23.2±1.5	23.9±1.0	p>0.05
Height (cm)	165.9± 6.3	163.5±5.0	
Body Weight (kg)	54.8±5.9	56.8±5.3	
BMI (kg/m²)	19.9±1.8	21.2±1.9	

BMI: Body Mass Index **SD:** Standard Deviation **Group 1:** Kinesiotaping intervention **Group 2:** Control group

Quadriceps femoris and Hamstring muscle groups was first repeated 15 times at a speed of 30°/sec, and then, repeated 15 times at a speed of 120°/sec. During training, subjects were verbally encouraged to apply maximum strength towards the Isomed 2000 device.

Kinesiotaping: A KT certified physiotherapi st administered Kinesiotaping applications. A standard 5-cm pink kinesio tex gold tape was used. Kinesotapes were applied according to the Kinesiotaping Manual Guidelines recommended by Kenzo Kase (15). Kinesiotaping was applied on M. Rectus femoris, Vastus Medialis Obliquus (VMO) and Hamstring muscles. Taping was applied just after the fatigue protocol, and removed at the 2nd day measurement. Muscle facilitation technique was used to increase activation of muscle and blood circulation, in order to benefit from effects of fatigue training.

Kinesiotaping on M. Rectus Femoris: The tape was measured from anterior inferior iliac spine (AIIS) to tuberositas tibiae, and was cut. The ends of the tape were cut in y shape. The tape was fixed from the AIIS to the top of the patella, using the muscle facilitation technique. Kinesiotapes were applied starting from the origin to insertion points of the muscle, in order to activate and facilitate the muscle innervation and circulation, and were stretched approximately between 10-30%, while the patient was lying on her back. The ends cut in Y shape were then stretched approximately between 50% and 75%, and fixed from the upper edge of the patella to the tuberositas tibia, while the patient was exercising maximum hip and knee flexion (Figure 1a).

Kinesiotaping on M. Vastus Medialis Obliquus: The same technique was used on VMO, starting from the linea aspera to tuberositas tibia (Figure 1b).

Kinesiotaping on M. Biceps Femoris: The tape was measured from the ischial tuberosity to the head of fibula and was applied with 30% stretching tape. The ends of tape cut in "Y" shape were then stretched 50-75%, and fixed from beginning of the tendon of biceps femoris to the head of fibula and 1/3 lateral of popliteal fossa. The tape was applied from the ischial tuberosity to 1/3 lateral of popliteal fossa and head of fibula using the muscle facilitation technique. This was applied while the subjects were standing, and flexing their body maximum forward from the hip with 30% stretching tape (Figure 1b).

Kinesiotaping on M. Semitendinosus and Semimembranosus: Kinesiotaping was performed in the same position as for the biceps femoris muscle, from ischial tuberosity to pes anserinus towards medial tibial condyle, applied with 30%

Table 2. Inter-group differences of Visual Analog Scale scores at rest and during activity, at different measurement times.

Visual Analog Scale		1 st test		2nd test		3rd test		4th test	
		Mean±SD	p	Mean±SD	p	Mean±SD	p	Mean±SD	p
Resting	**Group 1**	2.3±1.9	0.632	2.5±1.9	0.714	2.5±1.6	0.015	0.5±0.5	<0.001
	Group 2	2.6±1.4		2.7±1.5		4.0±1.6		1.8±1.0	
Activity	**Group 1**	3.6±1.8	0.714	3.8±1.9	0.852	4.4±1.7	0.078	1.6±0.8	0.001
	Group 2	3.9±1.8		3.9±1.5		5.7±2.0		2.8±1.0	

*p<0.05: Statistically significant SD: Standard Deviation Group 1: Kinesiotaping intervention Group 2: Control group 1 st test: Before kinesiotaping; 2nd test: 1 hour after training; 3rdtest: Day 2; 4th test: Day 7.

Table 3. Comparison of peak torque values of the groups for 30˚/s and 120˚/s velocities at different measurement times

Peak Torque (N_m/kg)			Pre-training		1 st test		2nd test		3rd test		4th test	
			Mean±SD	p	Mean±SD	p	Mean±SD	p	Mean±SD	p	Mean±SD	p
Flexion	30º/s	Group 1	2.68±0.63	0.889	2.56±0.78	0.965	2.66±0.66	0.537	2.84±0.72	0.009	2.99±0.63	0.064
		Group 2	2.64±0.83		2.58±0.93		2.49±0.87		2.15±0.62		2.48±0.84	
	120º/s	Group 1	2.56±0.66	0.636	2.42±0.69	0.618	2.43±0.58	0.364	2.65±0.62	0.002	2.82±0.68	0.060
		Group 2	2.43±0.85		2.57±0.96		2.18±0.89		1.95±0.53		2.27±0.87	
Extension	30º/s	Group 1	1.88±0.35	0.267	1.77±0.32	0.596	1.74±0.37	0.926	1.61±0.32	0.121	1.77±0.29	0.433
		Group 2	2.02±0.38		1.84±0.44		1.75±0.46		1.43±0.31		1.67±0.4	
	120º/s	Group 1	1.82±0.37	0.607	1.72±0.3	0.577	1.63±0.25	0.779	1.49±0.27	0.389	1.74±0.26	0.196
		Group 2	1.75±0.45		1.79±0.4		1.66±0.37		1.40±0.35		1.59±0.37	

*P<0.05: Statistically significant SD: Standard Deviation Group 1: Kinesiotaping intervention Group 2: Control group 1 st test: Before kinesiotaping; 2nd test: 1 hour after training; 3rdtest: Day 2; 4th test: Day 7.

stretching tape, and the ends of tape were cut in "Y" shape, then stretched 50-75%, and fixed from beginning of the tendon of semitendinosus and semimembranosus to pes anserinus and 1/3 medial of popliteal fossa (Figure 1b).

Isokinetic Test: The Isomed 2000 (Multi-Joint-System D+R Ferstl GmbH, Hemau, Germany) isokinetic system was used to measure the eccentric M. Quadriceps femoris and hamstrings peak torque (PT) (Figure 2) (1). During the test, measurements were taken while cases were in a sitting position with a 90° hip flexion, and knee movement angles at 10° and 85° flexion (means 0° knee extension). The arm of the dynamometer, that makes the knee flexion extension movement, was fixed to the distal end of the tibia with velcro tape. The test measurement protocol was designed to be at a speed of 30°/sec and repeated five times as the eccentric-eccentric contraction for both M. Quadriceps femoris and hamstrings of both groups.

DOMS pain: The Visual Analogue Scale (VAS) was used to measure delayed onset muscle soreness (16). A 10-cm horizontal line was numbered from 0 to 10; 0 expresses "no pain," and 10 expresses maximum, unbearable pain. Subjects were asked to mark the level of their pain on the line.

Data Analysis

Statistical analysis was performed using SPSS 16.0 software (SPSS Inc, Chicago, Illionis). Data were expressed as mean ± standard deviation (SD). Changes over time were analyzed separately using 2-way (group by time) repeated-measures analysis of variance (ANOVA) to determine differences between and within groups. This study has 80% power with 5% Type 1 error level and a difference of 0.3 Nm/kg for peak torque from baseline was statistically significant for 31 healthy subjects. Values of p<0.05 were considered significant.

RESULTS

There was no difference in age, height, body weight, and body mass index between groups in

Figure 1. Kinesiotaping application on M. Rectus femoris (a) and hamstring muscles (b).

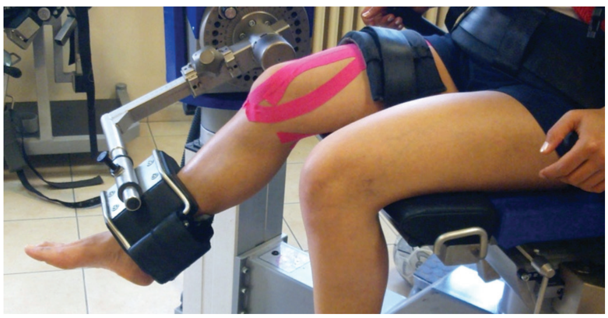

Figure 2. Isokinetic test with Isomed 2000.

the pre-test session (p>0.05, Table 1).

DOMS Pain: Pain levels were similar in both groups before Kinesiotaping and one hour after fatigue training (p>0.05). There was a significant difference in favor of Group 1 according to the values of VAS at rest on the 2nd day (p=0.015). There was also a statistically significant difference in favor of Group 1 in VAS values at rest (p<0.0001) and activity on the 7th day (Table 2).

Muscle Strength: Flexion and extension muscle strength at speeds of 30°/sec and 120°/sec before training, after application of Kinesiotaping and 1 hour later following training were similar between groups (p>0.05, Table 3). According to measurements taken at 30°/sec and 120°/sec speeds, there was a statistically significant difference in favor of Kinesiotaping group in terms of flexion peak torque on the 2nd day (p<0.05). In contrast, there was no statistically significant difference in extension PT in both groups on the 2nd day (p>0.05, Table 3). Similarly, peak torque measurements were similar in both groups on the 7th day.

DISCUSSION

The present study demonstrated that Kinesiotaping significantly alleviated DOMS pain on the 2nd and 7th days and improved hamstring muscle strength following eccentric fatigue training on the 2nd day. These results might provide a clue that thigh Kinesiotaping intervention following eccentric fatigue training has positive effects on pain alleviation and muscle force enhancement due to DOMS.

DOMS pain and loss of strength arises from damage to muscle fibers, muscle fatigue due to lactic acid and creatine kinase accumulation, degradation of connective tissue and fascia structure, muscle spasms, decrease of afferent inputs and inflammation (2,5-7,17-21). DOMS and strength loss reach their maximum value within 24-48 hours following eccentric fatigue protocol or eccentric training (2,5-7). According to a study by Cheung et al., one of the reasons why DOMS pain reaches a maximum value within 48 hours is the increase in the permeability of the muscle cell membranes via creatine kinase levels as a result of muscle damage. Consequently, mediators such as monocyte, prostaglandin, histamine, and bradykinin accumulate within the cell at the highest level, and the highest free nerve ending stimulation occurs during this period, so DOMS pain reaches its peak value (17). These studies support our results that M. Quadriceps femoris strength in both groups is the lowest in the 2nd day, as a result of DOMS. Similarly, the highest value of DOMS pain level was recorded on the 2nd day. Hody et al. has stated that eccentric training induces muscle stiffness, DOMS and strength loss for M. Quadriceps femoris following training immediately (11).

Cornish et al. found that after eccentric training at maximal isometric force, fatigue and DOMS significantly increase in the 2nd and 3rd days, but these effects doesn’t sustain in the next days (22).

According to a study conducted by Serrão et al., the highest decrease in strength of M. Quadriceps femoris muscle occurs in both M. Vastus lateralis (VL) (63%) and M. Vastus medialis obliquus (VMO) (66%) muscles on the 2nd day. The study concluded that VL muscle recovers a week later, and returns to its pre-exercise level at the end of the 2nd week, and was in a better level compared to its previous level (5). Similarly, in our study, muscle strength and DOMS pain reached the worst level on the 2nd day. All of these values improved on the 7th day, but did not return to values first recorded before fatigue training. Kinesiotapes were kept on the muscles until the end of 2nd day following intervention, and then kept away from the skin. In our opinion, the effect of the taping is mostly seen in the 2nd day; however, the tissue continued to activate the proprioceptors and blood flow process much better even after the tapes kept away from the skin. Therefore, the positive effects of kinesiotaping might be still remaining in the 7th day. Similarly to our results, Miller at al. showed the positive effect of the kinesiotaping for blood flow when they applied kinesiotape following submaximal biceps curl exercises (23). Moreover, Cho et al. also demonstrated that applying kinesiotape with proper tension may increase proprioception and may stimulate the muscle and also can decrease pain with older patients (24).

There are some conflicting arguments about the effects of Kinesiotaping on pain. Various studies support our research findings by indicating that Kinesiotaping reduces fatigue, causes a better healing of fascia, and decreases pain and edema (9,10,12,25-27). In contrast to these studies, Firth et al. have stated that Kinesiotaping had no effect on pain and motoneuronal excitability (28). We applied Kinesiotapes using muscle facilitation technique just following acute fatigue training, but in the study of Firth et al., Kinesiotaping was applied for chronic Achilles tendinopathy, used only tendon correction technique. As the kinesiotaping applied to the direction of the muscles targeting Golgi tendon organ; autogenic inhibition can be alleviated. In addition, it is regarded that promotion of metabolism resulting from inducement of muscle contraction was effective in reducing pain. VAS results in our study showed that there was a pain decrease in Kinesiotaping group. This might be a result of Kinesiotaping that affects subjective pain perception (24).

On the contrary to our study, Shoger et al. explained that Kinesiotaping application didn't reduce DOMS pain and swelling on wrist flexors after a DOMS protocol (29). We particularly chose a large group muscle to see the effects of Kinesiotaping after fatigue training clearly because the feeling of DOMS pain on M. Quadriceps femoris and hamstring is expected to be more than wrist flexors.

As a result in our study, Kinesiotaping intervention provided a decrease in feeling of DOMS pain during activity and at rest in mostly on hamstring muscles on the 2nd day. According to Sangnier et al., the hamstring muscle group contains more Type 2 muscle fiber than M. Quadriceps femoris. Type 2 muscle fibers are capable of rapid contraction and rapid fatigue, and are more sensitive towards fatigue (7,30). Therefore, hamstring muscle group may be prone to DOMS accompanying with strength loss following the eccentric fatigue protocol. M. Quadriceps femoris was less affected in the manner of fatigue; therefore kinesiotaping might have less effect on this muscle. Similarly, in our study, M. Quadriceps femoris muscle strength did not improve after fatigue training. In addition, there was a statistically significant difference between two groups in terms of strength measured on the 2nd day (in favor of Kinesiotaping group). The circulation deteriorates further as a result of ongoing muscle spasms since the damage to the sarcomere structure was pursued until day 2 (5,7, 17). However, we believe that Kinesiotaping may slow down strength loss by recovering connective tissue and removing inflammatory mediators due to properties such as increasing circulation and fascia relaxation (12).

Literature emphasizes that DOMS pain and strength losses occur after eccentric training, and reach their maximum value on day 2. The reason of higher level of DOMS in hamstrings in our study might be the fact that hamstring muscles contain more Type 2 muscle fibers in comparison to M. Quadriceps femoris; therefore, a higher level of muscle fiber damage following fatigue training results with higher inflammatory reactions (9,11,30). Additionally, thigh Kinesiotaping following eccentric fatigue training is effective on pain alleviation and muscle force enhancement due to delayed-onset muscle soreness on day 2.

There are some limitations in the methodology of the study. The serum creatine kinase levels, blood markers and fatigue levels of subjects were not measured in the study. In addition, the eccentric fatigue training protocol was not based on a certain protocol.

The results of the study aimed to open an additional perspective about application of kinesiotaping, which may decrease pain and DOMS after eccentric training. Future studies should utilize larger sample sizes with blood markers (such as creatine kinase) to analyze the role of Kinesiotaping on DOMS following the fatigue training process.

Conclusions

Kinesiotaping intervention might be an additional treatment intervention for DOMS pain and strength loss in terms of possible improvements in hamstring strength and hamstring pain level after eccentric fatigue training in healthy females.

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