Songklanakarin J. Sci. Technol.
43 (1), 269-274, Jan. - Feb. 2021

http://www.sjst.psu.ac.th

Original Article

Elastic taping has little effect on recovery of anaerobic power after intensive exercise in untrained females

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Received: 16 August 2019; Revised: 12 November 2019; Accepted: 15 December 2019

Abstract

This study aimed to evaluate the effect of elastic tape compared to placebo tape and static stretching on recovery of anaerobic power after intensive exercise in untrained females. Thirty-two untrained female volunteers were randomized into an elastic tape (n= 11), a placebo tape (n = 11) or a stretching group (n =10). Prior to, and for up to 7 days after exhaustive eccentric exercise, Kinesio elastic tape and placebo tape were applied to the dominant quadriceps of taping groups, while the stretching group performed static stretching on the quadriceps for 30s x 10 sets 3 times a day. There was no significant difference in muscle pain, creatine kinase, maximum isometric voluntary contraction, jump height and anaerobic power between the three groups over the course of the study. In untrained females, elastic tape did not improve recovery of anaerobic power after exhaustive eccentric exercise compared to placebo tape or static stretching with no tape.

Keywords: eccentric exercise, Kinesio tape, muscle soreness, stretching, Wingate test

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1. Introduction

Traditionally, medical tape has been used on athletes in a preventative manner aimed at reducing potential injury, but recently a type of medical tape commonly known as Kinesio tape has become popular as a means of improving recovery and performance. Kinesio tape comprises hypoallergenic, latex free cotton fiber with acrylic adhesive glue. The waterproof feature reinforces the tape to maintain skin contact for up to 3-5 days. Kinesio tape can be stretched up to 140% of its resting length, and after being applied, the tape will attempt to recoil back to original length (Kase, Wallis, & Kase, 2003). The reported beneficial effects of Kinesio taping include pain reduction, increased proprioception, increased muscle performance and enhanced lymphatic and blood flow (Kase, Wallis, & Kase, 2003). Changes in such physiological mechanisms with Kinesio taping may help promote recovery of muscle weakness, pain and tenderness after intensive exercise (Boobphachart, Manimmanakorn, Manimmanakorn, Thuwakum, & Hamlin, 2017).

Because of the reported physiological changes that accompany elastic taping, some researchers have attempted to use elastic taping as an aid to improve anaerobic performance. Kim and Seo (2012) found in a cross-over study that mean and peak power outputs during a 30-s Wingate test significantly increased after Kinesio tape was applied on the quadriceps muscle, compared to no taping. On the other hand, in a randomized controlled trial study, Harmanci *et al*. (2016) using a similar Wingate test, found no significant change in anaerobic power or capacity between the elastic taping and non-taped groups. While the effect of elastic tape such as Kinesio tape on immediate anaerobic performance is controversial, the effects of elastic tape on the recovery of anaerobic performance indicators after intensive exercise is relatively un-researched. In the one study on this topic, Szymura *et al*. (2016) revealed there was no significant effect of Kinesio tape (applied to gastrocnemius and quadriceps muscles immediately after downhill running and remained on the subjects for 48 hours) on peak or mean power output values during recovery from intensive exercise (60 min downhill running) compared to the passive recovery (lying 45 min in supine position with legs raised 5º). However, peak and mean power output recovered to baseline levels in the Kinesio group more quickly than in the passive recovery group (at 24- hours post-eccentric exercise in Kinesio group and 48- hours post-eccentric exercise in passive recovery group).

Unfortunately, Szymura *et al*. (2016) used a passive control group (rather than a control or placebo group) which may have resulted in a placebo effect in the taped group compared to the passive control group which could account for the improved anaerobic performance recovery.

From the previous studies, it is unclear whether the Kinesio tape has a beneficial effect on anaerobic performance or not. Therefore, this study aimed to evaluate the effect of elastic tape compared to a similar looking placebo tape or more traditional method (static stretching) on the recovery of anaerobic performance after exhaustive eccentric exercise. From the mechanism of Kinesio tape, we hypothesized that Kinesio tape would improve anaerobic performance more than placebo tape and stretching method. In addition, all previous studies have investigated the effects of Kinesio taping on anaerobic performance in only male volunteers; in this study, for the first time, we investigated the effects of Kinesio taping on anaerobic performance in female participants.

2. Materials and Methods

2.1 Study design and participants

Thirty-two untrained healthy female volunteers who did not have regularly exercise or involvement in sport activity were included in this study (40.8 ± 8.7 years, height 156.2 ± 7.1 cm, weight 59.9 ± 7.2 kg, BMI 24.6 ± 3.1 kg.m^{-2}, mean ± SD). Participants completed a health-risk questionnaire and medical examination by a qualified medical physician one week prior to commencement of the study. The participants were excluded if they had serious medical problems such as uncontrolled cardiopulmonary disease or neuromuscular disorders, or had a history of musculoskeletal problems in the lower limbs. We also excluded volunteers who had contraindications for taping (e.g. skin infections or an open wound). Participants were advised not to use any analgesic medication designed to relieve exercise-induced muscle pain during the study. Participants were also asked to refrain from dietary supplements, or performing any sport activities or unaccustomed exercise during the data collection period. The protocol of this study was approved by the local Ethics Committee for Human Experimental Research (HE 571222). This study has been registered as a clinical research trial (TCTR20141215001).

2.2 Procedures

This study is an extension of previously reported research (Boobphachart *et al*., 2017) where the participants were randomly allocated into 3 groups: elastic tape (n=11), placebo tape (n =11) and stretching groups (n=10). Unlike previous research, taping and stretching were applied before the exercise protocol. The tape (both elastic and placebo) was maintained on the muscle for the complete 7-day post-exercise period. The exhaustive eccentric exercise was conducted on the dominant knee extensor muscles using an isokinetic dynamometer (Primus RSTM, model: PR30, BTE® technology, USA). Prior to exercise, a 5-min warm up on a stationary cycle ergometer (Monark Ergomedic 894E Peak Bike, Sweden) at 50% of maximum heart rate was completed. The participants were secured to the dynamometer chair in a seated position using waist and thigh straps. The range of motion during the exhaustive exercise was from 0° to 90° of knee extension (0° = full extension). Participants performed 4 sets of 25 maximal voluntary eccentric contractions at a velocity 60º.s^{-1} separated by 3 min rest between sets (Vila-Chã, Hassanlouei, Farina, & Falla, 2012). Visual feedback and verbal encouragement were given to facilitate maximal effort. The participants were familiarized with the dynamometer machine (performed one or two contractions with very low load) approximately 1 week before commencing the experiment.

2.3 Intervention

The elastic tape (KINESIO® TEX GOLD, Kineso Holding Corporation, Georgia, USA) was applied to the participants in the elastic tape group by the researcher who had received certified training from Kinesio Taping Association. Kinesio elastic tape of 5 cm width and 20 cm length was applied on the rectus femoris, vastus medialis and vastus lateralis muscle using the facilitation technique (origin to insertion) (Kase *et al*., 2003) (Figure 1A). Initially, the participant rested on the examination table with both knees extended. Elastic tape was strapped to the anterior inferior iliac spine, and then applied along the rectus femoris of the dominant thigh with tension (stretched to 125% of original length). The end of tape was split and strapped around the patellar as per standard instructions. For the vastus medialis, elastic tape was initially strapped on the superior shaft of the femur, and was applied on to the vastus medialis muscle in a downward direction to the knee with tension in the stretching position (hip flexion 120°, knee flexion 120° and hip external rotation 45°). After returning the hip and knee to the extended hip and knee position, the end of the tape was strapped on to the area medial to the patella. Finally, a section of tape was initially strapped on to the greater trochanter, and was strapped along the vastus lateralis with tension in vastus lateralis stretching position (hip flexion 120°, knee flexion 120° and hip internal rotation 45°). After the hip and knee joint were restored to the initial resting position, the end of the tape was strapped on to an area lateral to patella.

For the placebo group, small pieces of elastic tape were loosely applied to the quadriceps muscle during sitting with both knees extended. Three pieces of Kinesio tape (5 cm width, 10 cm length) were strapped along the longitudinal axis of the rectus femoris, vastus medialis and vastus lateralis just above the patellar with no tension applied (Figure 1B).

The participants in the stretching group performed static stretching on the dominant quadriceps muscle for 30s with a 10s rest for 10 sets 3 times a day for the duration of the study (Torres, Pinho, Duarte, & Cabri, 2013). For the stretch, the participants were in a standing position and bent their dominant knee, while their hand held the ankle and pulled the hip backward to a hyperextension position (Figure 1C).

The outcome variables including muscle soreness, pressure pain threshold, muscle strength, power and anaerobic performance were assessed at pre-exercise, immediately post-exercise and 1, 2, 3 and 7 days post-exercise, while serum creatine kinase activity was measured at the same time as other outcomes except immediately post-exercise.

2.4 Measurement

2.4.1 Muscle power

Muscular power (via the vertical jump test) was assessed by recording the best of 3 attempts (interspersed with 1 min recovery) of a maximal counter-movement jump test (Swift Yardstick Vertical Jump Tester, Australia) after giving standard instructions.

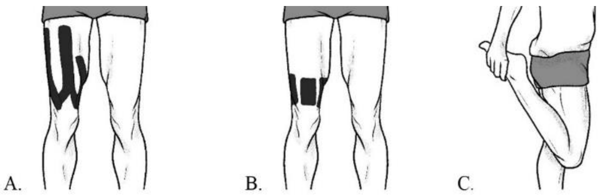

Figure 1. A. Elastic tape, B. Placebo tape, and C. Quadriceps stretching

2.4.2 Muscle strength test

Maximal isometric voluntary contraction (MVC) of the knee extensors was measured via the isokinetic dynamometer. The dynamometer was calibrated before testing according to the manufacturer's instructions. Volunteers sat in the reclined position (hip flexion 135°), and were strapped firmly at the hips and thighs to prevent extraneous movement. The center of the tested knee joint was aligned with the axis of the dynamometer. For the isometric MVC, the participants were asked to sustain a maximal effort for 6 s at fixed knee joint angle of 45° (0° is referred to as full extension). The participants were verbally encouraged to produce maximal force. The average of the highest peak force of 3 measurements (with 1 min rest between efforts) was recorded.

2.4.3 Anerobic power test

After a standardized 3-min warm-up where participants cycled at their own cadence without any resistance, participants performed a 30-s Wingate test on a stationary cycle ergometer (Monark 894E, Sweden) in which they pedaled maximally against a constant load (7.5% body mass) while seated (Bar-Or, 1987). Peak and mean power output along with the power decrease (peak – minimal power) was calculated.

2.4.4 Pain evaluation

Pressure pain threshold is the minimal pressure which produces an unpleasant painful sensation. Pressure pain threshold was measured by pressing down on the muscle in a perpendicular fashion with a manual algometer (BASELINE®, New York, USA) at three specified points (5, 10, and 15 cm above the apex of patella along the midline of thigh), while the participant was in the sitting position with legs straight out forward and quadriceps muscles relaxed. The mean value of the 3 sites was reported. Muscle soreness score was measured by self-rating muscle soreness scale, ranging from 0 (no pain) to 10 (worst pain).

2.4.5 Blood test

A 3-ml blood sample was drawn from the antecubital vein of the participants after 10 min prone rest and immediately assessed for creatine kinase activity by an automatic analyzer (COBAS INTEGRA 800, Roche Ltd., USA).

2.5 Statistical analysis

The statistical analysis of data was conducted using Stata statistical program version 13. The characteristics of participants were reported in descriptive statistics such as percentage, mean and standard deviation. The distribution of data was evaluated by the Shapiro – Wilk test which showed a non-normal distribution, therefore the Generalized Estimating Equations (GEE) were conducted for data analysis to compare the change within group compared to baseline and the difference among three groups. The statistically significant difference was accepted at a p-value less than 0.05.

3. Results

Characteristics of the participants in the three groups are presented in Table 1 and show no significant difference between groups. Perceived muscle soreness and creatine kinase activity increased significantly after exercise to peak between 24 to 48 hours post the exhaustive exercise and then gradually subsided. However, there was no significant difference in perceived muscle soreness, pressure pain threshold or creatine kinase activity between three groups during recovery (Table 2).

Vertical jump height significantly decreased immediately after exercise and slowly recovered in the three groups but no significant difference in vertical jump height was found between the three groups. The maximum voluntary contraction (MVC) decreased significantly in the stretching group immediately post-exhaustive exercise compared to baseline levels. However, compared to baseline, the MVC in the elastic tape and placebo tape group did not change throughout the 7-day recovery period (Table 2). There was no significant difference between three groups for MVC through-out the 7-day period. The anaerobic performance measures remained relatively unchanged in all three groups over the entire recovery period (Table 3).

Table 1. Participants' characteristics

Characteristic	Elastic tape	Placebo tape	Stretching
Number	11	11	10
Age (year)	42.0 ± 6.2	41.5 ± 9.7	38.9 ± 9.9
Height (cm)	152.6 ± 6.9	157.2 ± 7.1	159.0 ± 5.7
Weight (kg)	57.9 ± 8.2	62.1 ± 6.8	59.9± 6.4
BMI (kg.m^{-2})	24.9± 3.6	25.2 ± 2.6	23.8 ± 2.9

Data are means ± SD. BMI, body mass index.

Table 2. Outcome measures at baseline, immediately post-exercise and days 1, 2, 3 and 7 post-exercise

		Baseline	Post-immediate	Post-day 1	Post-day 2	Post-day 3	Post-day 7	p-value
MSS	ET	0±0	3.6±2.1^{a*}	3.3±1.3^{a*}	3.1±0.8^{a*}	2.3±1.0^{a*}	1.2±0.9^{a*}	0.126
	PT	0±0	4.6±1.9^{a*}	4.0±1.6^{a*}	3.4±1.6^{a*}	2.9±1.6^{a*}	1.6±0.8^{a*}	
	SC	0±0	3.6±1.3^{a*}	2.9±1.3^{a*}	3.2±1.6^{a*}	2.1±1.3^{a*}	1.1±1.2^{a*}	
PPT	ET	4.5±0.7	3.9±1.0	4.0±1.1	3.8±1.3	4.0±1.1	4.4±0.9	0.889
(kg)	PL	4.4±0.8	3.9±0.9	4.0±1.0	3.9±1.1	4.4±0.7	4.7±0.5	
	SC	4.6±0.5	3.9±0.8	3.9±0.9	3.8±0.8	4.0±0.9	4.6±0.4	
MVC	ET	6.5±0.9	5.9±0.9	6.6±1.5	6.7±1.8	6.8±1.6	7.1±1.1	0.559
(Nm)	PL	6.9±1.7	5.9±2.0	5.9±2.0	6.1±1.6	5.8±1.4	6.3±1.3	
	SC	7.1±1.0	5.5±1.1^{a*}	5.9±0.9^{c*}	6.0±1.0^{c*}	5.8±1.2^{c*}	6.4±1.3	
Vertical jump	ET	25.7±3.1	23.1±3.1^{c*}	24.1±4.3	23.8±3.8	24.5±4.1	24.3±4.8	0.967
(cm)	PL	25.6±4.6	23.0±3.7^{c*}	23.2±5.3	23.6±4.8	23.5±4.5	24.5±4.3	
	SC	25.7±4.7	22.5±3.9^{b*}	23.4±3.9	23.3±3.7	24.5±3.8	23.8±3.7	
CK	ET	125.3±26.6	-	221.1±100.9^{a*}	200.9±76.6^{a*}	167.1±65.9	139.9±32.2	0.358
(IU/L)	PT	136.2±48.7	-	186.1±65.1^{b*}	164.6±57.4	157.8±58.7	109.7±44.5	
	SC	117.6±23.9	-	169.5±57.0^{b*}	156.9±62.4^{c*}	151.8±63.6	111.4±34.3	

All values showed mean ± SD. *significant difference compared to baseline, ^{a*} p<0.0001, ^{b*} p<0.01, ^{c*} p < 0.05 (ET, Elastic tape; PT, Placebo tape; SC, Stretching; MSS, muscle soreness scale; PPT, pressure pain threshold; MVC, maximum voluntary contraction; CK, creatine kinase). The data showed no significant difference between three groups.

Table 3. Anaerobic power measures at baseline, immediately post-exercise and day 1, 2, 3 and 7 post-exercise

		Baseline	Post -immediate	Post day 1	Post day 2	Post day 3	Post day 7	p-value
Peak	ET	250.9±91.2	248.5±76.4	271.9±94.4	277.3±93.5	281.1±92.9	279.3±96.1	0.317
(watt)	PT	280.9±111.3	275.5±107.5	297.3±106.3	291.7±82.9	299.1±79.9	306.2±86.3	
	SC	242.5±55.4	224.4±59.2	241.0±52.9	244.6±54.6	251.8±54.1	251.3±43.9	
Mean	ET	196.3±78.4	194.1±65.2	205.8±77.2	211.7±77.4	218.2±79.8	216.2±77.1	0.219
(watt)	PT	208.4±60.6	196.8±64.4	218.5±72.5	219.2±56.4	228.9±65.2	226.7±58.9	
	SC	179.6±42.6	165.3±42.1	172.6±36.0	177.5±42.4	183.5±35.4	186.7±30.9	
Peak /kg	ET	4.2±1.3	4.2±0.9	4.5±1.3	4.6±1.3	4.6±1.3	4.6±1.3	0.371
(watt)	PT	4.5±1.6	4.4±1.6	4.7±1.5	4.7±1.0	4.8±1.0	4.9±1.1	
	SC	4.1±0.8	3.8±0.9	4.0±0.8	4.1±0.9	4.2±0.9	4.2±0.7	
Mean/kg	ET	3.3±1.1	3.2±0.9	3.4±1.1	3.5±1.1	3.6±1.1	3.6±1.0	0.229
(watt)	PT	3.3±0.9	3.2±0.9	3.5±0.9	3.5±0.7	3.6±0.7	3.6±0.8	
	SC	2.9±0.6	2.8±0.7	2.9±0.6	2.9±0.7	3.6±0.7	3.1±0.8	
Power	ET	2.1±0.8	1.9±0.5	2.4±1.0	2.3±0.6	2.5±0.8	2.4±0.6	0.588
decrease	PT	2.7±1.8	2.7±1.6	2.6±1.3	2.4±0.8	2.5±0.9	2.7±1.1	
/kg (watt)	SC	1.9±0.9	1.9±0.7	2.7±0.9	2.4±0.6	2.6±0.7	2.3±0.7	

All values showed mean ± SD. The data show no significant difference compared to baseline and no significant difference between and within ET and PT, ET and SC (ET, Elastic tape; PT, Placebo tape; SC, Stretching).

4. Discussion

This study revealed significantly higher levels of muscle soreness and pain, along with elevated levels of creatine kinase activity after intensive eccentric exercise which were not significantly different between the 3 groups. Moreover, muscle strength, muscle power and anaerobic power were not different between the groups suggesting static stretching, placebo taping and elastic Kinesio taping had the same effect over the study period.

The proposed mechanisms in which elastic tape may assist muscle performance enhancement include promotion of blood and lymphatic circulation by widening the space between the skin and muscle (Thelen, Dauber, & Stoneman, 2008), enhancing cutaneous mechanoreceptors and facilitating muscle contraction (Gilleard, McConnell, & Parsons, 1998). Such physiological changes with taping may have resulted in two previous studies indicating a beneficial effect of elastic taping on anaerobic power. Kim and Seo (2012) revealed elastic taping increased anaerobic power compared to baseline, and Szymura *et al.* (2016) found an improved anaerobic power recovery time after intensive eccentric exercise.

The current study however, showed no beneficial effect of elastic tape on anaerobic power recovery over a 7-day period. The results of our study corroborate findings from a previous study by Harmanci *et al*. (2016) that revealed no effect of elastic taping on anaerobic power. The present study used the facilitation taping technique compared to Szymura's study that used the lymphatic taping technique and applied the tape to both quadriceps and both gastrocnemius muscles (Szymura *et al*., 2016). The lymphatic technique or fan-shaped strip was developed to increase the area covered to enhance lymphatic and blood circulation. Castrogiovanni *et al.* (2016) revealed that the fanshaped strip technique reduced pain and improved function on osteoarthritis patients more than the stabilizing technique. Future research should look into the effect of using different taping techniques on performance recovery.

This study showed that the exhaustive eccentric exercise caused substantial muscle pain and elevated creatine kinase activity in the days following the exercise. The eccentric exercise probably caused substantial muscle damage (as evidenced by the elevated CK activity) and subsequent muscle pain. Such severe changes within the muscle cell resulted in the decreased strength and power that ensued over the next 7 days. We found no significant reduction in delayed onset muscle soreness (DOMS) or muscle strength in the elastic group which was surprising since previous research suggested that elastic tape can help reduce DOMS (Bae, Lee, Kim, & Kim, 2014; Boobphachart *et al*., 2017; Lee, Bae, Hwang, & Kim, 2015) and enhance recovery of muscle strength (Alam, Malhotra, Munjal, & Chachra, 2015; Vered, Oved, Zilberg, & Kalichman, 2016).

It must be noted that the current study was conducted on female participants who have anatomical differences from the males in the previous studies (Kim & Seo, 2012; Harmanci *et al*., 2016; Szymura *et al*., 2016). For example, females have twice the amount of adipose tissue at the front of the thigh area compared to males (Leahy, Toomey, McCreesh, O'Neill, & Jakeman, 2012). We speculate that the high adipose content of the females' thighs in this study may have altered the effects of the elastic tape on widening the interstitial tissue area under the skin and therefore reduced any circulation improvement to the muscles. Future research should look to investigate the effect of local adipose tissue content on tissue circulation change in muscle with elastic taping.

This study found that static stretching along with elastic or placebo taping had no significant effect on anaerobic power recovery. Previous studies also suggest static stretching had little effect on either mean power or peak power recovery measured by the Wingate test (Franco, Signorelli, Trajano, Costa, & de Oliveira, 2012; Oshita, Yamaguchi, & Ariyoshi, 2016). It has been suggested that static stretching is unhelpful in promoting muscle recovery after the muscles are damaged from intensive exercise (Torres *et al*., 2013). We found static stretching after exhaustive eccentric training significantly decreased MVC strength up to three days post-exercise, which was not mirrored by the other two groups. Previous work indicates that static stretching can reduce force production, possibly via altered mechanical or neural properties of the muscle (Cramer *et al*., 2004). We postulate that the increased muscle damage via the eccentric exercise load along with the daily static stretching, inhibited force production ability of the muscles in the stretching group. It is important for strength and conditioning professionals to be concerned that stretch exercise for improving muscle recovery would reduce muscle strength and reduce sport ability in the near future competition.

A limitation of this study is the generalizability of the results since we included untrained females with a mean age of 40.8 ± 8.7 years (mean ± SD), these results may not be applicable to younger trained females. Additionally, the results of this study may not be applied to males, particularly well-trained males.

5. Conclusions

Elastic tape applied to the quadriceps muscle of untrained females using the facilitation technique provided no additional benefit to muscular strength, muscular power or anaerobic power recovery compared to placebo tape or static stretching with no tape. We therefore advise caution when using such tape on untrained females.

Acknowledgements

We acknowledge the Research Center in Back, Neck, Other Joint Pain and Human Performance, Khon Kaen University for the research funding grant number 57212111 and Graduate School Khon Kaen University for the research funding grant number 5701. Special thanks to Dr. Kaewjai Thepsuthammarat and Associate Professor Dr. Bandit Thin-khamrop from Khon Kaen University for statistical analysis.

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