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Effects of Kinesio taping on calf muscle fatigue in college female athletes

A randomized controlled trial

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Abstract

Background: Fatigue is a common phenomenon encountered by athletes in ordinary life and sports. Fatigue results in decreased muscle strength, balance, agility, and an increased risk of injury, which together results in hampered sports performance. Several studies have examined the effects of Kinesio Tape (KT) application on muscle fatigue however, contradictory findings are reported. This study aimed to examine the effects of the application of KT on calf muscle fatigability.

Methods: A three-arm parallel pretest-post-test experimental design was used. Forty-five collegiate female athletes (mean age of 20.57 years) were randomly assigned to three groups. For the experimental group, KT with 50% tension; for the sham group, KT without any tension; and for the placebo group, rigid tape without any tension was applied. The number of heel rises (HR_n) was measured before and after taping in the three groups, using Haberometer and Metronome. The tapes were applied in the Y shape to the calf muscle region.

Results: In the experimental group: The HR_n significantly increased by 18.76 % (P = .000) after applying KT. In the sham and placebo groups: There was no change in HR_n before and after Taping (P > .05).

Conclusion: Y-shaped application of KT with 50% tension over the calf muscle region is effective in reducing its fatigability.

Abbreviations: HR = heel rise, HR_n = number of heel rises, KT = Kinesio tape.

Keywords: calf muscle, heel-rise test, Kinesio taping, muscle fatigue

1. Introduction

Athletes encounter fatigue both in ordinary life and in sports. Fatigue can be defined as the reduced ability of a muscle to generate force during a contraction that gradually develops after the onset of prolonged physical activity.[1] Fatigue results in several harmful consequences, such as reduced strength,[2,3] agility,[4] balance,[3] and increased risk of injury,[2] which collectively results in decreased sports performance.[5] Kinesio tape (KT) is becoming popular among athletes to improve their performance, especially after Olympic athletes started using it.[6]

In the last few years, several studies have been performed to assess the therapeutic effects of KT on various aspects like flexibility,[7] movements kinematic,[8] proprioception,[9] muscle strength,[10–12] blood circulation,[13] pain,[14] delayed onset muscle soreness,[15] range of motion,[16] and balance.[17] However, many studies have reported contradictory findings regarding the therapeutic effects of KT.[6] Similar is the case with fatigue, where different studies have reported contradictory results.

Several factors are related to the development of muscular fatigue, such as the central nervous system-related, psychological, peripheral, and cellular factors.[18] Several studies have proposed that KT increases blood and lymph circulation, muscle activity, and proprioception[19,20] thereby it may reduce the harmful effects of fatigue.[21] Kase[19] suggested that an increase in blood and lymph circulation might support the transport of oxygen and exudates and aid cellular metabolism; as a result, muscle function might be improved.[22] Similarly, Kataoka and Ichimaru reported an increase in peripheral blood circulation due to KT after 20 minutes of cycling.[20] In addition, Alvarez-Alvarez et al[21] reported that the time to failure increased in lumbar extensor muscles after applying KT.

However, some studies had not reported any benefit of KT on muscle fatigue. A study by Lins et al[23] argued that the tension generated by the tape is insufficient to increase the interstitial space in a rested condition to increase blood flow. A study by Stedge et al[13] reported no effect of KT when applied over gastrocnemius muscle on the endurance ratio over 30 isokinetic maximal plantar and dorsiflexion or on blood circulation.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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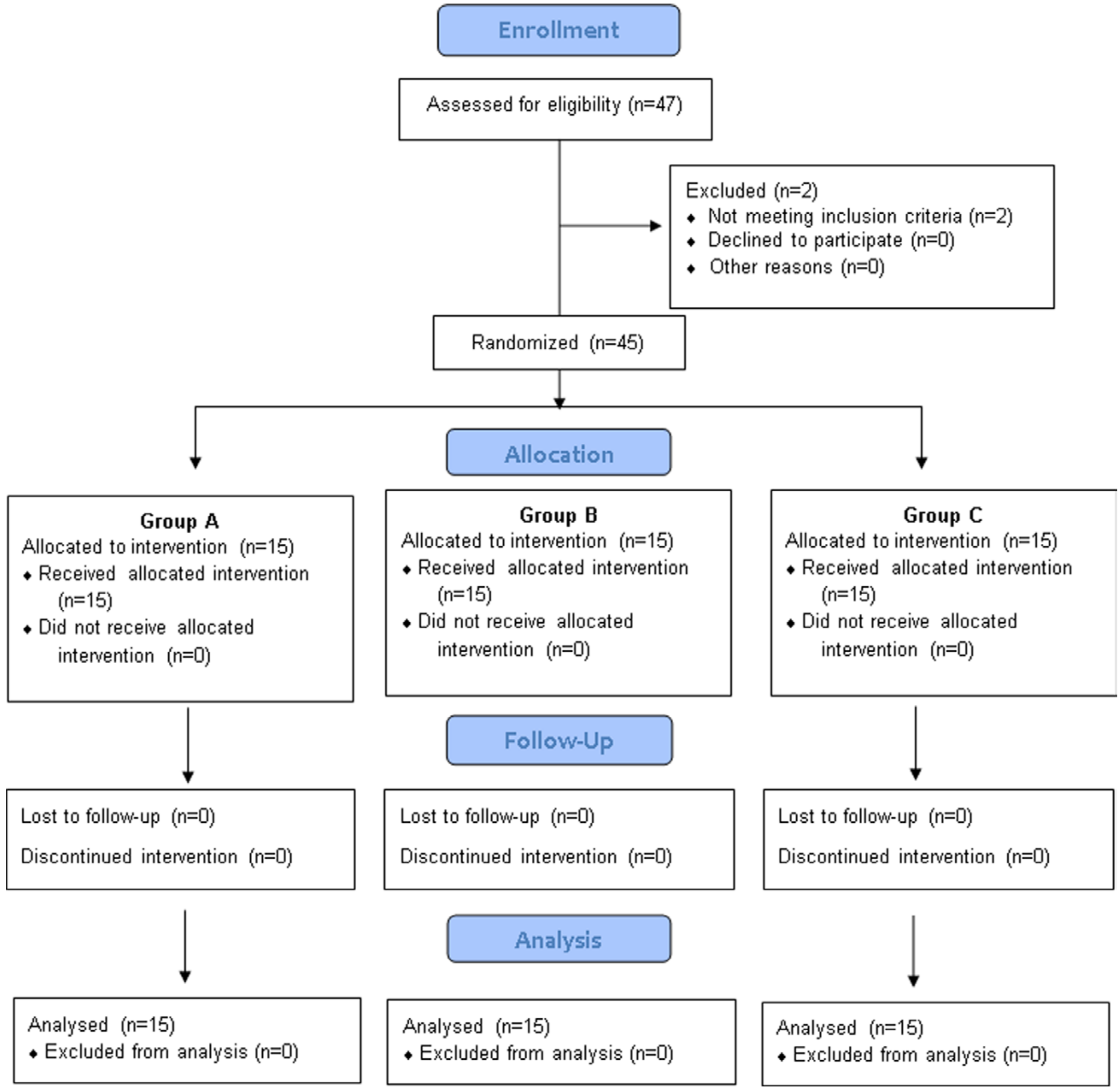

Figure 1. CONSORT flow chart of the study showing the recruitment of participants.

Therefore, these findings indicate the contradictory role of KT in minimizing the adverse effects of fatigue.

KT is easy to apply over the muscle region and will not restrict joint movements. Thus, if the application of KT is proved effective in reducing the effects of fatigue on muscle performance, then the application of KT can be recommended for athletes during sports. Therefore, a study was warranted to examine the acute effects of KT on muscle performance measured by the heel rise (HR) test when applied to the calf muscle. Therefore, this study aimed to examine the acute effects of KT application on fatigability in the calf muscles. We hypothesized that KT application has a significant role in reducing calf muscle fatigability when applied over it.

2. Methods

2.1. Study design and setting

This study had a 3-arm comparative pretest–post-test experimental research design, randomly allocating an equal number of participants into three groups (experimental, sham, and placebo). This study was registered prospectively on clinicaltrials.gov (ID: NCT04960865) under the protocol registration and results system.

2.2. Participants

For experimental research, group sizes of approximately 30 participants are considered the minimum size to make a valid generalization.[24] Therefore, a total of 45 female college athletes (mean age 20.57 years, standard deviation (SD) 1.92) were selected for the study (Fig. 1 and Table 1). The inclusion criteria for the selected athletes were: college female athletes of the age group 19-25 years who participated in training at least three times a week, and the participants should perform a minimum of 25 HR.[25] The exclusion criteria were: participants with a history of musculoskeletal injuries in the dominant lower limb, cardiopulmonary, vestibular, or neurological complications, and any systemic disorder diagnosed by a physician. Also, participants who consumed any pre-workout supplements in the last six months

Table 1

Respondent's demographic and variables data, n = 15 in each group.

	Experimental group	Sham group	Placebo group
	Mean (SD)	Mean (SD)	Mean (SD)
Age, years	20.66 (2.28)	20.00 (1.85)	21.06 (1.53)
Height, cm	153.53 (7.24)	156.13 (6.85)	153.73 (4.43)
Weight, kg	48.94 (4.40)	51.94 (7.85)	50.74 (5.34)
BMI, kg/m^2	20.88 (2.51)	21.33 (3.12)	21.48 (2.26)
HR Pre, n	34.46 (4.24)	32.33 (5.71)	34.46 (5.99)
HR Post, n	40.93 (6.00)	34.00 (6.82)	33.06 (4.55)

BMI = body mass index, HR = heel-rises, SD = standard deviation.

were excluded from the study. According to the study's inclusion and exclusion criteria, participants were selected and randomly assigned to one of the three groups using the lottery method and the website Randomization.com (http://www. randomization.com) by an expert physiotherapist with 15 participants in each group: Experimental, Sham and Placebo group. A total of 45 chits, numbered 1 to 45, were placed in a box. For each participant included in the study, the physiotherapist picked a chit from the box, and that number was assigned to that participant. Random permutation of integers from 1 to 45 was generated for three groups using the website randomization.com and participants were allocated into the experimental, sham, or placebo group accordingly. The participants were unaware of the random sequence. The outcome assessor, who was different from the physiotherapist who generated the random allocation sequence, was also unaware of allocation and tape application. The study was carried out according to the Declaration of Helsinki guidelines. The Ethics Sub-Committee of the Institutional Review Board approved it (protocol code: RRC-2021-05 and date of approval 2 March 2021). The study was conducted on university premises from 6 September 2021 to 22 December 2021.

In the experimental group, KT was applied over the calf muscle with 50% stretch; in the sham group, KT was applied with 0% stretch; and in the Placebo group, the rigid tape was applied with 0% stretch. Before the application of any intervention, the risks and benefits of the study were discussed with the participants, and informed consent was obtained. The number of heel-rises (HR_n) was the dependent variable, and taping method was the independent variable.

2.3. Instrumentation

- Kinesio tape (Nasara kinesio tape™)
- Rigid tape
- Haberometer
- Metronome

2.4. Study protocol

This study consisted of 3 phases: pre-intervention evaluation, intervention, and post-intervention evaluation.

2.4.1. Preintervention evaluation. Participants were asked to refrain from physical activities on the day of evaluation. Only the dominant lower extremity of the participants was evaluated, which was identified following a procedure that involved the participant kicking the ball, which was thrown towards them. Calf muscle fatigue was assessed using the HR test. To standardize the HR test, Haberometer and Metronome were used.

A Haberometer is a device specifically designed to standardize the HR test. It is a reliable tool to measure calf muscle fatigability in healthy individuals.[26] Before the preintervention evaluation, the rod and foot positioning device in the Haberometer was adjusted to limit the height of each HR to 5 cm. A Metronome was also used to regulate the speed of the HR test. It is a device that generates sounds at a fixed interval. Users set this interval as the number of beats per minute.

The HR_n measurements: in the standing position, participants bent their non-dominant knee so that it was suspended in the air, and the test limb was in a weight-bearing position with the foot bare.

Participants were asked to follow the sounds/beats of the metronome. At the first beat of the metronome, the participant lifted her heel until her navicular bone touched the rod of the Haberometer; then, this position was maintained until the next beat, at which the heel was lowered, and then the participant waited for the next beat. This heel raise and drop were performed at the rate of 23 lifts/minute, that is, 46 beats/minute.[26] For balance, participants were allowed to hold their hands against the wall. Participants had to perform this heel raise and drop until they could not maintain the pace of 23 lifts/minute, or they could not touch their navicular bone with the rod. Participants performed these movements in the presence of a physical therapy assistant so that incorrect or trick movements were avoided.

2.4.2. Intervention.

1. In group A (experimental) - Participants were asked to lie prone on a couch with both lower limbs straight and feet off the edge of the couch with a towel placed underneath the feet. Pink-coloured Kinesio tape was applied in the form of a Y-strip with 50% stretch over the calf muscle region (Fig. 2). Three points, that is, proximal, mid, and distal, were marked with a pen over the skin with the ankle at maximum dorsiflexion. The proximal point was marked 4 cm below the popliteal line, which denoted the origin of the calf muscle, and the distal point at 3 cm below the upper part of the posterior tuberosity, which indicated the insertion of the calf muscle, and the midpoint at the mid of proximal and distal points.
   The following sequence was used for tape application: the tape was cut into a Y strip, the ankle joint was kept in a neutral position, and both proximal ends of the Y strip were placed at the proximal line over the lateral borders of the calf muscle, now participants were asked to perform maximum dorsiflexion at the ankle, then the proximal halves of both strips were stretched to 50% and placed up to the midpoint, while maintaining ankle dorsiflexion, the distal halves of the Y strip were also stretched to 50% and placed from the midpoint to the upper part of the posterior tuberosity of the calcaneus and now ankle was brought to the neutral position, and distal ends of the strip were placed without any tension at the distal line (Fig. 2).[17]
2. In group B (sham) – blue coloured Y-strip KT was applied similarly as in group A from the origin of calf muscle near the knee joint to its insertion near the heel but without any tension. The same reference points were marked and used for tape application.

Figure 2. Application of Y-shape Kinesio tape over calf muscle.

3. In group C (placebo) – white coloured Y-strip of rigid tape was applied similarly as in groups A and B from the origin of the calf muscle near the knee joint to its insertion near the heel without any tension. The same reference points were marked and used for tape application. The same physical therapist applied tapes to the three groups to maintain uniformity in tape application.

2.4.3. Post-intervention evaluation. After a 30-minute gap, HR_n was measured again similarly as in the case of preintervention evaluation.

Outcome measure: The number of heel-rises (HR_n).

2.5. Data analysis

SPSS statistical software, version 26 (SPSS Inc., Chicago, IL), was used for all data analyses. Data from 45 participants, 15 participants from each group, were analyzed. The normal distribution of the baseline values of the dependent variable (HR Pre) was evaluated using the Shapiro–Wilk normality test, which revealed the normal distribution in all three groups (Group A, $P = .441$; Group B, $P = .288$; Group C, $P = .054$). Therefore, parametric tests were used for with-in and between-group analyses. Paired sample test and one-way analysis of variance (ANOVA) were used for with-in-group and between-group comparison, respectively. *P*-value < .05 was considered significant, and the confidence interval was set at 95%.

3. Results

3.1. With-in group comparison (paired samples test) (Table 2)

- Group A: There was a significant increase in HR_n by 18.76% ($P = .000$) after applying KT under 50% tension.
- Group B: There were no significant differences in HR_n before and after the application of sham KT (without any tension) ($P = .136$).
- Group C: There were no significant differences in HR_n before and after applying the placebo rigid tape ($P = .262$).

3.2. Between-group comparison (one-way ANOVA) (Table 3)

One-way ANOVA (Bonferroni) revealed a significant difference in mean HR_n differences between groups A and B ($P = .020$) and groups A and C ($P = .000$). There was no significant difference in mean differences of HR_n between groups B and C ($P = .226$). Table 4 shows the effect size for one-way ANOVA.

4. Discussion

This study aimed to examine the effects of KT on muscle fatigue in the calf muscle. Results of the present study showed that KT when applied under tension, increased the resistance of calf muscle to fatigue. Those participants who had KT applied under tension to the calf muscle could perform more HR_n than those who had sham KT or placebo rigid tape. Furthermore, the present study revealed that there was no difference in HR_n between sham KT and placebo rigid tape.

In the present study, calf muscle fatigue was assessed using the HR test because the standing HR test assesses the endurance capacities of the calf muscle in a closed kinetic chain.[25] In one of the previous studies, when participants had performed the standing HR test to exhaustion, a significant decrease in work was observed, as well as a reduction of the electromyographic mean power frequency of the calf muscle.[27] Therefore, these findings suggest that the standing HR test causes fatigue of the calf musculature.[28] In the present study, participants who were able to perform a minimum of 25 HR were recruited because, according to Lunsford and Perry,[25] individuals performing a minimum of 25 HR can be considered normal.

The results of the present study indicate that the mechanism associated with muscle fatigue is influenced in some way by the application of KT. One of the possible explanations could be that KT may improve intramuscular blood flow. When muscles contract isometrically beyond 20% of maximum voluntary contraction, blood flow inside intramuscular capillaries is reported to decrease to 30 to 40 mm Hg.[29] As a result, oxygen supply is reduced and algogenic substances such as bradykinin and lactate are not drained.[30] It is hypothesized that lymphatic drainage[19] and blood flow[20] improve after applying KT to muscles. KT is assumed to improve blood circulation because it stimulates the autonomic nervous system, causing vasodilation in the area where KT is applied. Therefore, this improved lymphatic drainage and blood flow may increase oxygen supply and help to remove an increased amount of lactate and bradykinins, thus increasing muscle resistance to fatigue. Another mechanism proposed to support the role of KT in decreasing pain after fatigue is

Table 2

With-in group comparison (paired samples test) for all three groups.

Groups	Mean difference (HR post-HR Pre) (SD)	t	df	*P*-value
Experimental	6.46 (5.04)	4.96	14	.000*
Sham	1.66 (4.08)	1.58	14	.136
Placebo	−1.40 (4.64)	−1.16	14	.262

HR = heel-rises; SD = standard deviation.
*Significant.

Table 3

Results of the comparison between groups (one-way ANOVA).

(I) Group	(J) Group	Mean difference (I-J)	Std. error	P-value
Experimental	Sham	4.80	1.68	.020*
Experimental	Placebo	7.86	1.68	.000*
Sham	Placebo	3.06	1.68	.226

*Significant.

Table 4

Effect size for one-way ANOVA.

	Sum of squares	df	Mean square	F	P-value	Partial Eta squared
Contrast	471.644	2	235.822	11.120	.000*	0.346
Error	890.667	42	21.206			

*Significant.

the facilitation of pain-gate control theory.[31] Other studies suggested that KT can improve EMG activation of the vastus medialis oblique muscle, increase stability sensation and decrease pain perception when applied to the knee joint.[32] In addition, some studies have reported an increase in muscle strength during concentric contraction,[33] isometric contractions,[34] and a normalization of muscle tone[35] after applying KT. Also, Slupik et al[36] reported increased EMG activity of quadriceps muscle after 24 hours of KT application. This might be partially attributed to the muscle alignment/activity and pain relief produced by KT.

In addition to the mechanisms mentioned above, some placebo factors could contribute to muscle resistance to fatigue. Applying KT can psychologically affect individuals, causing changes in their expectations and behavior that may lead to more positive performance.[21]

However, contrary findings have also been reported, for example, Fu et al[12] did not find significant differences in inhibition or facilitation of hamstring and quadriceps muscle strength. Furthermore, Poon et al[37] and Chang et al[10] reported no significant changes in muscle strength immediately after KT application. A recent study by Lee et al[38] reported that KT does not have significant positive effects on self-perceived fatigue level, muscle endurance, strength, and power. Some studies did not report an immediate increase in functional performance of healthy individuals without pain due to muscle fatigue after KT application, regardless of the deception of the participants and changes in tape tension.[39] The reason could be that these participants had good functional performance and were pain-free. Similarly, Yeung et al reported that with KT application, the time to reach peak torque generation was reduced in knee extensors; other than this, there was no positive effect on muscle performance.[40]

The present study showed that when KT was applied to the calf muscle, it increased the resistance of the muscle to fatigue; therefore, KT can be applied to the calf muscle when athletes want to delay fatigue in this muscle. The results of the present study also have clinical implications, as the results indicate that KT when applied under tension, can significantly reduce the fatigability of the calf muscle; therefore, it can be used in clinical settings and sports activities to enhance muscle function and thus improve the overall performance of individuals.

There are certain limitations in the present study, like the small sample size used. Furthermore, in the present study, fatigue was measured with a single variable only, that is, HR_n; however, this single variable may not provide sufficient details regarding the fatigue mechanism and how KT affects it; therefore, further studies are needed that examine other variables as well, such as the concentration of lactate in blood or EMG. Furthermore, HR_n was measured immediately after the application of KT; therefore, further studies should examine the medium and long-term effects of KT so that possible immediate effects of skin proprioception with the application of KT can be ruled out. Another limitation is the inclusion of only female participants; therefore, the results of the present study cannot be generalized to male participants due to hormonal differences. Furthermore, the fatigability of the calf muscle was measured using the HR test in a controlled environment, which includes only a single movement; however, in many sports, there is a combination of different movements. Therefore, further research should test the fatigability of calf muscle in athletes during actual sports. The present study supported using KT to reduce fatigue; however, whether KT application improves athletes' performance during sports needs to be further evaluated.

5. Conclusion

The results of the present study accept the experimental hypothesis and conclude that the Y-shaped application of KT under tension has a significant role in reducing fatigability in calf muscle in collegiate female athletes.

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