Effect of Kinesio Taping on Jumping and Balance in Athletes: A Crossover Randomized Controlled Trial

Guilherme S. Nunes,[1] Marcos de Noronha,[1,2] Helder S. Cunha,[1] Caroline Ruschel,[1] and Noé G. Borges Jr,[1]

[1]*Department of Physiotherapy, Center of Health and Sport Sciences, Santa Catarina State University, Florianópolis, Brazil; and* [2]*Department of Allied Health, La Trobe Rural Health School, Bendigo, Australia*

Abstract

Nunes, GS, de Noronha, M, Cunha, HS, Ruschel, C, and Borges Jr, NG. Effect of Kinesio Taping on jumping and balance in athletes: A crossover randomized controlled trial. *J Strength Cond Res* 27(11): 3183–3189, 2013—The purpose of this crossover randomized controlled trial was to verify the effect of Kinesio Taping (KT) applied to the triceps surae with the aim to improve muscle performance during vertical jump (VJ), horizontal jump (HJ), and dynamic balance (DB) in healthy college athletes. The participants were 20 athletes (11 men) who competed in 4 different sports modalities (track and field, handball, volleyball, and soccer). Participants had a mean age of 22.3 ± 3.3 years, mean height of 1.74 ± 0.08 m, and mean body mass of 67.8 ± 10.1 kg. The intervention consisted of applying KT from the origin of the triceps surae to its insertion with the purpose of increasing muscle performance, and the placebo consisted of applying tape with nonelastic properties. There were no significant differences between KT and placebo conditions for height (m) in VJ (KT, 0.18 ± 0.06; placebo, 0.17 ± 0.06; $p = 0.14$), distance (m) in HJ (KT, 1.48 ± 0.3; placebo, 1.47 ± 0.3; $p = 0.40$), and DB in distance reached (m) in the star excursion balance test, normalized by lower limb length (anterior: KT, 90.0 ± 6.7; placebo, 89.5 ± 7.5; $p = 0.56$; posterolateral: KT, 92.5 ± 7.5; placebo, 93.2 ± 5.8; $p = 0.52$; posteromedial: KT, 98.3 ± 6.7; placebo, 98.7 ± 7.4; $p = 0.69$). The KT technique was not found to be useful in improving performance in some sports-related movements in healthy college athletes; therefore, KT applied to the triceps surae should not be considered by athletes when the sole reason of the application is to increase performance during jumping and balance.

Key Words postural balance, elastic bandages, sports performance

Address correspondence to Guilherme S. Nunes, nunesguilherme@live.com.

27(11)/3183–3189

Journal of Strength and Conditioning Research

Introduction

Functional taping has been used for some time in different ways and for various purposes, but mainly to stabilize injured joints (11). Other indications and techniques have been proposed including Kinesio Taping (KT), a method created by Kase et al. (12) in 1973. This technique has been widely disseminated, especially in the field of sports, as its aims are to enhance normal functional movements, decrease pain, and decrease swelling. Despite being a popular therapeutic tool, it was only recently that its effects started to be investigated via randomized clinical trials (8,19,23). Among the studies on the effectiveness of the KT technique, some have already investigated its effects on trunk range of motion (23), shoulder pain (19), and cervical pain (8). These studies found that KT can improve trunk range of motion in healthy individuals and relieve shoulder and cervical pain, particularly in the acute stage; however, little has been investigated regarding its popular use to increase performance through muscle stimulation.

The application of KT with the specific aim of improving muscle contraction is generally recommended for specific conditions such as when the muscle fails to receive proper nervous stimuli or when the aim is to stimulate the muscle while performing a specific movement, i.e., sports-related movements with consequent improvement in the performance of these movements. Previous studies have been carried out with the purpose of verifying the effect of KT on muscle function (3,14,20). Vithoulka et al. (20) investigated the effect of KT on quadriceps strength in 20 healthy nonathlete women. They compared KT with placebo taping and no taping and found that KT may have increased eccentric strength by a margin of 6%. Lins et al. (14) also investigated the influence of KT on quadriceps in 60 healthy female college students who were active but nonathletes. To that purpose, the participants were divided into 3 groups of 20 participants each (KT, nonelastic tape, and control), and their findings suggest that KT was not capable of improving function, balance, strength, or muscle activities (14). Chang et al. (3) also investigated the effect of KT applied to enhance muscle function; however, they applied the KT to forearm muscles and analyzed force sense and maximal handgrip strength in 21 healthy male college students. To that purpose, KT was compared with placebo taping and no taping. The results suggest that KT was capable of improving handgrip force sense; however, there were no significant differences in maximal handgrip strength. Thus, the current literature shows some evidence that KT may affect some muscle groups, perhaps in different ways; however, the literature is considerably scarce in that matter.

Also, the physiological explanation behind KT application is scarce. It is assumed that KT can facilitate and stimulate muscle function if its application starts at the origin of the muscle and ends at its insertion (12). It is suggested that this form of application could stimulate muscle function because of the elastic properties of the KT. Theoretically, the elastic fibers of the KT would shorten toward the first site it is applied to, in this case, the origin of the muscle (12,20). Therefore, the elastic fibers of the KT could stimulate the muscle in the direction of muscle contraction, improving movement (12,20). Hypothetically, KT would stimulate cutaneous mechanoreceptors and increase recruitment of motor units (18). Another raised hypothesis is that the KT could stimulate the fascia providing higher tension to muscle facilitating the muscle contraction (20).

If the hypothesis behind KT application is correct, then it is logical to expect that KT could be beneficial in activities that have a more functional approach, such as jumping. Jumping is a common movement seen in different sport modalities and usually critical to performance. The vertical jump (VJ), for example, requires a complex motor skill that involves several muscles, including the quadriceps and triceps surae (6,21). The quadriceps muscle has a great influence on the performance of the VJ, whereas the triceps surae muscle is equally important for jumping (1,22). This can be observed in a study that assessed performance in the VJ of 6 healthy participants, before and after their triceps surae had been fatigued. It was observed that, after fatigue, the jump was significantly lower (1), showing the importance of this muscle group in the VJ. Therefore, considering the importance of the triceps surae during jumping and the suggestion that KT can improve muscle performance, it is feasible to question whether KT application to the triceps surae is able to improve VJ performance with the aim to improve sports performance. Therefore, the purpose of the present study was to verify the effect of KT on the triceps surae muscle while performing 3 functional activities, that is, VJ, horizontal jump (HJ), and dynamic balance (DB) in healthy college athletes. We hypothesized that KT applied to the calf of healthy individuals would influence their performance during the jumps and the DB task.

Methods

Experimental Approach to the Problem

This was a crossover randomized controlled trial aimed to verify whether the application of KT could stimulate the triceps surae and consequently improve the performance of the participants in jumping activities and postural control. Participants were submitted to 2 identical test sessions (test-retest); however, one under KT application and the other under placebo tape application (nonelastic tape). The order in which the KT or placebo was applied was randomly decided (KT before placebo or KT after placebo). The sessions consisted of tests that measured jump height in the VJ, distance reached in HJ, and DB (dependent variables). Overall, the performance of 20 assessments run with KT application was compared with that of the placebo (Figure 1).

Subjects

Twenty healthy college athletes (11 women and 9 men; age, 22.3 ± 3.3 years; height, 1.74 ± 0.08 m; body mass, 67.8 ± 10.1 kg) from Santa Catarina State University (UDESC) who were regularly engaged in training and competition in 4 sports modalities (12 track and field athletes, 4 volleyball athletes, 2 handball athletes, and 2 soccer athletes) agreed to participate in this study. To be included, the participants had to be training at least 3 times a week at competition level and be free from prior vestibular or neurological changes or any musculoskeletal injury that could interfere with or contraindicate the assessment procedures. This study was registered in the Brazilian Clinical Trials Registry (RBR-4t949d) and approved by the Human Research Ethics Committee of UDESC (protocol no. 89/2011). All participants signed the consent form before any data collection.

The assessments were conducted at the UDESC Physical Therapy School Clinic in a quiet room with no external interference. The assessments happened within a month in spring, and the test-retest occurred at the same time of day with a minimum interval of 48 hours and a maximal interval of 1 week. This short time interval between the test-retest was selected to avoid interference of external factors. The participants were instructed to avoid all physical activity on the day of the assessment, to wear athletic training attire, and to take the same care with feeding and hydration on both days of assessment. To reduce bias, the assessor was not involved in the taping, and the researcher who applied the tape also covered it with a sock, which was worn for the duration of the assessment (Figure 2A). Therefore, both the assessor and the participant were blinded to the type of tape. The order of the tests (VJ, HJ, and DB) was also randomized.

Procedures

Concealed allocation was performed using sealed opaque envelopes prepared by a researcher who was not involved in the recruitment or assessment of the participants (Figure 1). Only one of the lower limbs of each participant was assessed, and the side to be assessed (right or left) was randomly decided. After this, the therapist would prepare the participant for taping by shaving the respective calf. The therapist would then open the sealed opaque (coded) envelope. With that information, the therapist would apply the KT or placebo with the participant in prone with hips and knees fully

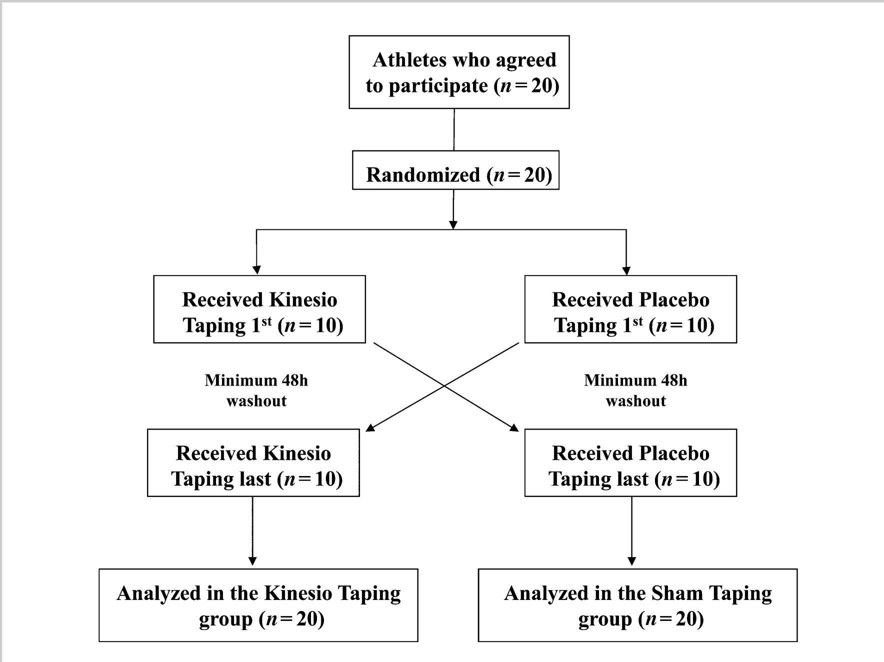

Figure 1. Flow chart.

extended and feet off the edge of the treatment table to be able to perform maximum ankle dorsiflexion during taping.

To ensure blinding, the therapist cut the strip in a separate room and covered it with a sock immediately after application (Figure 2A). The participant's eyes were also covered during taping. Tape application was always performed by the same therapist, who was specifically trained for this study.

Kinesio Taping. All participants underwent the same Y-shape application from the origin of the triceps surae up to its insertion (knee region to heel [Figure 2B]). This technique was intended to stimulate the muscles based on the method by Kase et al. (12) (Figure 2B). Reference points for tape application were located 4 cm below the popliteal line and 3 cm below the upper part of the posterior tuberosity of the calcaneus. The points were marked on the ankle at maximum dorsiflexion (Figure 3A). Tape color was beige, and stretching tension was 50%. The KT was applied by an assessor who received KT training and followed the principles suggested by Kase et al. (12) when targeting muscle contraction improvement.

Taping was applied in the following order (Figure 3): (a) the tape was cut into a Y-strip so that each side could be taped longitudinally along the borders of the gastrocnemius; (b) both the proximal ends of the Y-strip were placed, free of tension, 4 cm below the popliteal line with the ankle in the neutral position (Figure 3B); (c) the proximal half of the strip was then stretched and placed on the calf up to the marked midpoint with the participant's ankle at maximum dorsiflexion (Figure 3C); (d) the distal half of the strip was also stretched and placed from the midpoint to the upper part of the posterior tuberosity of the calcaneus with the participant's ankle still at maximum dorsiflexion (Figure 3D); and (e) the distal end of the Y-strip was then placed, free of tension, with the ankle back in neutral position (Figure 3E).

To ensure that tape tension on the skin would be as close

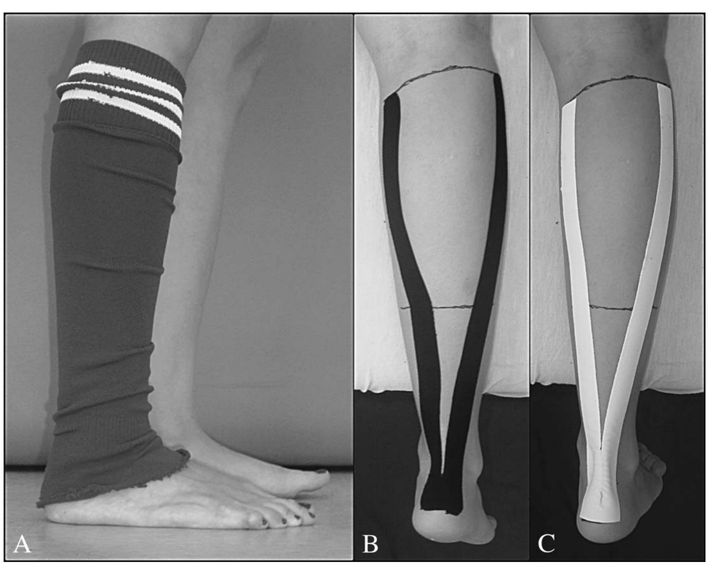

Figure 2. Interventions. A) Blinding with a sock. B) Application of Kinesio Taping. C) Application of placebo (nonelastic tape).

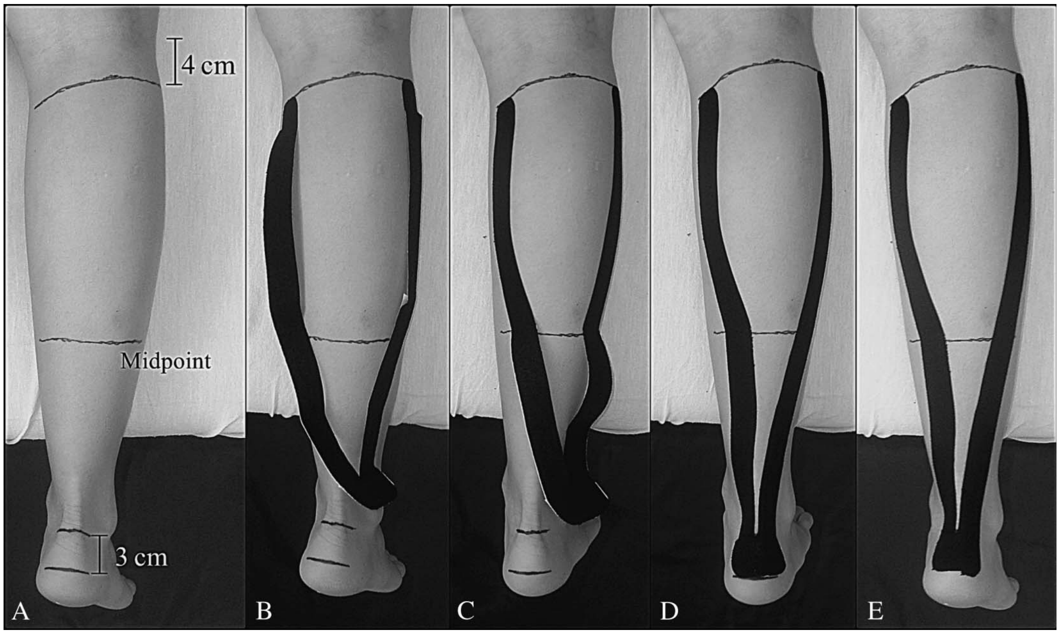

Figure 3. Elastic tape application diagram. A) Reference markings for application. B) Application of the proximal ends of the Y-strip. C) Application of the proximal half up to the midpoint. D) Application of the distal half from the midpoint to the upper part of the posterior tuberosity of the calcaneus. E) Application of the distal end of the Y-strip.

as possible to 50% and that the application procedure was standardized for all participants, the distance between the extreme reference points in the stretched position was measured (Figure 3A), which is the distance equivalent to the final length of tape after application (Figure 3E). To determine the length of tape to be cut, the following calculations were made: final length (FL) of tape minus 6 cm (which is the length of the tails of the Y-strip applied with no tension) divided by 1.5 (referring to 50% tension to be applied) to find the original length of tape (X in Figure 4B), which will receive tension during application (Figure 4A). This length (Figure 4B) is added by the length of the tails (6 cm) plus 25%, referring to the pretension with which the tape is sold (2) (Figure 4B).

$$\text{Length of tape to be cut (cm)} = \left[\left(\frac{FL-6}{1.5}\right)+6\right]\times 1.25.$$

Placebo. For the placebo taping, we used nonelastic adhesive tape, which was cut to the same size as the elastic tape, both transversely (5 cm) and longitudinally (distance between the point located 4 cm below the popliteal line and 3 cm below the upper part of the posterior tuberosity of the calcaneus at maximum passive dorsiflexion). The application followed the same instructions as of the KT application for the length of tails, shape of strip, and direction of application. Given that the adhesive tape is practically nonelastic, there was no tape tensioning in the placebo application (Figure 2C).

After tape application, the participants were sent to another room to be assessed. The purpose of the assessments was to analyze VJ, HJ, and DB. All assessments were performed by a single assessor.

Familiarization and Warm-Up. The participants warmed up for 5 minutes by walking on a treadmill at a comfortable speed, then they carried out 10 submaximal single leg jumps (5 VJs and 5 HJs) on both lower limbs to complete the warm-up. Assessment procedures were duly explained, and the participants were instructed to repeat the jumps as many times as they felt necessary to feel comfortable before performing the assessment. Most participants performed 2 familiarization trials (apart from the warm-up) and informed the researcher that they were ready for the assessment.

Vertical Jump. Vertical jump was used as a measure of performance as it is a common sports-related movement that requires power of the triceps surae (13,16,22). Vertical jump was assessed by measuring flight time with the aid of a contact mat (SaltoBras, Florianópolis, Brazil) developed and validated specifically to record flight time during a jump (2,5). The participants were instructed to maintain single leg stance on the mat with hands on hips and jump as high as possible with countermovement, landing on the assessed

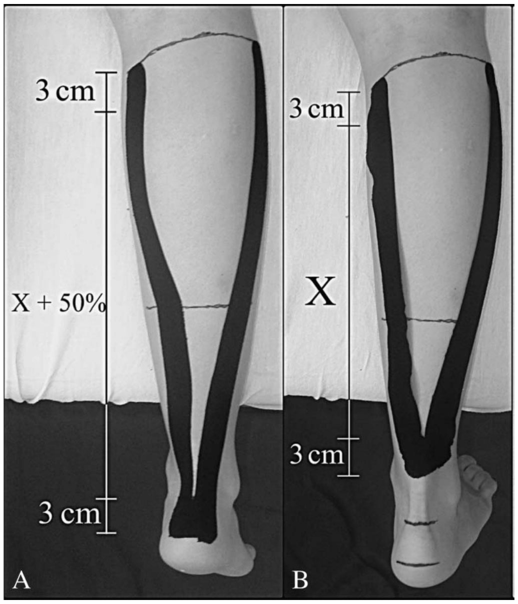

Figure 4. Tape cutting diagram. A) Total length of tape. B) Partially applied strip of tape to represent original length of tape free of tension (X).

lower limb. Three valid jumps were collected. Participants were verbally encouraged to jump as high as possible, and they were allowed to rest for at least 1 minute between jumps. A jump was considered invalid if the participant used the upper limbs for propulsion, landed outside the contact mat, or flexed hips and knees during the flight phase. The following formula was used to calculate jump height:

$$h = 0.5(t/2)^2 g,$$

where "h" is the jump height in meters, "t" is the flight time in seconds, and "g" is gravity acceleration (9.81 $m \cdot s^{-2}$) (5).

Horizontal Jump. Horizontal jump was used to assess the participant's function and performance (7,17). The participants were asked to maintain single leg stance on the assessed lower limb with the anterior extremity of the foot placed immediately before a line drawn on the floor. They were not allowed to move the upper limbs by placing hands on hips. From this position, each participant jumped as far as possible, landing on the same limb and keeping the limb on the landing spot so the distance could be measured. The distance considered for analysis was measured from the most posterior point of the heel up to the first marking. Three valid jumps were recorded. The participants were verbally encouraged to jump as far as possible. They were allowed to rest for at least 1 minute between jumps. A jump was considered invalid if the participant used the upper limbs for propulsion or when they moved their foot from the landing spot.

Dynamic Balance. Dynamic balance was assessed by the Star Excursion Balance Test (SEBT) (10). Initially, the participants maintained single leg stance on the assessed lower limb at the intersection of 3 lines drawn on the floor extending in 3 directions: anterior (SEBT Ant), posterolateral (SEBT PL), and posteromedial (SEBT PM) according to Gribble and Hertel (9). The 2 posterior lines were at a 90° angle to one another and at a 135° angle to the anterior line. The position of the supporting foot was controlled by keeping the lateral malleolus aligned to the center of the grid and by keeping the third toe aligned with the anterior line drawn on the floor. The participant was instructed to touch each line as far as possible with the hallux of the opposite foot, and the distance reached by the participant was recorded. The procedure was repeated 3 times for each direction. For data analysis, the distance reached was normalized by dividing it by the length of the lower limb and multiplying it by 100. Lower limb length was considered as the distance between the anterior superior iliac spine and the medial malleolus (9).

Statistical Analyses

Considering a power of 80% and alpha of 5%, a minimum paired sample size of 20 participants was necessary to

Table 1. Comparison between Kinesio Taping and placebo taping.*†

Assessment	KT	Placebo	Mean difference	95% CI of the difference	p
Flight time, s	0.38 ± 0.07	0.37 ± 0.06	0.005	−0.002 to 0.013	0.15
Vertical jump, m	0.18 ± 0.06	0.17 ± 0.06	0.006	−0.002 to 0.013	0.14
Horizontal jump, m	1.48 ± 0.3	1.47 ± 0.3	0.02	−2.49 to 5.99	0.40
DB in SEBT Ant, %	90.0 ± 6.7	89.5 ± 7.5	0.51	−1.29 to 2.31	0.56
DB in SEBT PL, %	92.5 ± 7.5	93.2 ± 5.8	−0.71	−2.99 to 1.58	0.52
DB in SEBT PM, %	98.3 ± 6.7	98.7 ± 7.4	−0.36	−2.23 to 1.51	0.69

*Data are shown as mean ± *SD* (*t*-test; significance level $p < 0.05$).
†KT = Kinesio Taping; DB = dynamic balance; SEBT = Star Excursion Balance Test; Ant = anterior; PL = posterolateral; PM = posteromedial.

identify a 2-cm VJ difference between conditions, assuming an *SD* of 3 cm (15). Descriptive statistics was used to show mean and *SD*, and the normal distribution of the data was verified by the Shapiro-Wilk test. After confirming normal distribution of the data, the *t*-test for dependent samples was used for between-condition comparisons (KT vs. placebo) for all variables investigated (flight time, VJ, HJ, and DB in SEBT Ant; DB in SEBT PL; and DB in SEBT PM). For data analysis, we used the best results obtained in each assessment for each variable.

The significance level was set at $p < 0.05$, and the analyses were performed using Statistical Package for the Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA).

Results

All participants completed both assessments as set forth by randomization (Figure 1). Therefore, it was shaped into 2 groups: KT group with 20 participants and placebo group with 20 participants. The dominant lower limb was evaluated in half of the participants. Mean, SD, and the mean difference (95% CI) between both conditions are shown in Table 1. Comparison between KT and placebo conditions presented no differences in the performance of VJ (flight time, $p = 0.15$; height of VJ, $p = 0.14$), HJ (distance of HJ, $p = 0.40$), or DB (SEBT Ant, $p = 0.56$; SEBT PL, $p = 0.52$; SEBT PM, $p = 0.69$).

Discussion

This study assessed the effect of the stimulus provided by KT on the triceps surae of healthy athletes. This effect was verified via VJ, HJ, and DB performance. There were no effects of KT on the performance of the VJ and the HJ. An earlier study investigated the effect of KT applied to stimulate the function of the quadriceps on isokinetic strength by comparing a KT group, a placebo group, and a tape-free group (20), and unlike the present study, it found a difference in muscle strength. The eccentric strength for the quadriceps for the KT group was higher than that of the remaining groups; however, the effect of KT was only assessed with an isokinetic dynamometer, and no other assessment that reflects function was included. Furthermore, the effect observed during the eccentric phase of the movement did not occur in the concentric phase (20). Increase in muscle performance provided by KT may not have been detected in the present study because of the fact that (a) VJ and HJ peak performance occurred immediately after the concentric contraction of the main muscles involved, and eccentric contraction may not be directly associated with performance in these assessments and (b) isokinetic assessment may not clearly represent the performance achieved during a sports-related movement, as these movements never occur at constant speed. Thus, the findings of the present study show that KT application to the triceps surae does not provide performance improvement during jumping. However, possible gains in strength may not be detectable during functional assessments but only with more specific tests, such as those conducted by Vithoulka et al. (20).

When KT is used to stimulate muscle function, as advocated by the creator of KT (12), we would expect some improvement in some tasks that depend on muscle function, such as the jumps in the current study. However, our findings do not corroborate the suggestion made by Kase et al. (12). When KT is applied to stimulate the triceps surae, it seems incapable of increasing the motor unit recruitment that generates improved performance in athletes, whether by the stimulation of the central or peripheral structures.

Additionally, the present study found no effect of KT on balance. Few studies have investigated this issue; however, the study by Cortesi et al. (4) found possible benefits of KT to the balance of individuals with multiple sclerosis. The KT was applied to the Achilles tendon region and showed decreased displacement of the center of pressure in the anteroposterior direction. However, these results should be considered with caution, as the study did not use a control group for comparison and did not include any blinding (participant or assessor) during data collection and analysis. Nevertheless, considering the association of these indications and the claims by Kase et al. (12) that KT is capable of improving muscle function, it would be reasonable to expect improvement in muscle strength and motor control and consequent improvement in balance. So far, however, there is no evidence that KT has any effect on motor control, which could also help to explain the absence of KT effect on balance in the present study.

Another possible explanation for the lack of positive results for all assessed variables is related to the characteristics and size of the sample. The results of the present study showed a much greater *SD* than expected for the primary variable; therefore, the sample size would have to be considerably larger to detect a 2 cm difference between conditions in the VJ. One possible explanation for such a large *SD* may be the variability in jump height achieved by the participants. Our sample comprised athletes of both genders who competed in varied sports modalities, and after revisiting the raw data, we noticed that the male participants had consistently higher jumps when compared with the female participants and that could have had an impact on the *SD* and consequently in the statistical analysis. Also, the population comprised athletes, which suggests that performance level for balance and muscle function was already near maximum limits and that possible gains provided by the KT were not significant or detectable by the performance tests used here. During training and competitions, athletes constantly face situations that stimulate their balance and muscles and require them to improve these aspects to maintain performance. It is possible that KT could have a more significant influence on nonathletes with weak balance and strength or at least on athletes who were not training regularly.

The KT technique was not found to be useful in improving performance in activities that involve jumping (vertical and horizontal) and balance. Future studies to verify its effect on other muscle groups activated during the assessed activities may lead to a better understanding of how KT can affect performance. Studies involving participants with balance and strength deficits may also clarify whether KT could play a more relevant role in a population with needs other than those presented in this study.

Practical Applications

Our findings showed that KT is no different to rigid tape and is unlikely to have any effect on jump height and distance or balance when applied to the triceps surae of college athletes. Resources and time would probably be better used if directed to other means that might have better chances of effectively improving performance. Nevertheless, KT application did not deteriorate performance, thus it could be used if it increases comfort during the athlete's sports activities.

References

1. Bobbert, MF, van der Krogt, MM, van Doorn, H, and de Ruiter, CJ. Effects of fatigue of plantarflexors on control and performance in vertical jumping. *Med Sci Sports Exerc* 43: 673–684, 2011.
2. Borges, NG Jr, Borges, L, Dias, JA, Wentz, MD, Mattos, DJS, Petry, R, and Domenech, SC. Validity of a new contact mat system for evaluating vertical jump. *Motriz: rev educ fís* 17: 26–32, 2011.
3. Chang, H-Y, Chou, K-Y, Lin, J-J, Lin, C-F, and Wang, C-H. Immediate effect of forearm Kinesio taping on maximal grip strength and force sense in healthy collegiate athletes. *Phys Ther Sport* 11: 122–127, 2010.
4. Cortesi, M, Cattaneo, D, and Jonsdottir, J. Effect of kinesio taping on standing balance in subjects with multiple sclerosis: A pilot study. *NeuroRehabilitation* 28: 365–372, 2011.
5. Dias, JA, Dal Pupo, J, Reis, DC, Borges, L, Santos, SG, Moro, ARP, and Borges Jr, NG. Validity of two methods for estimation of vertical jump height. *J Strength Cond Res* 25: 2034–2039, 2011.
6. Ebben, WP, Simenz, C, and Jensen, RL. Evaluation of plyometric intensity using electromyography. *J Strength Cond Res* 22: 861–868, 2008.
7. Firth, BL, Dingley, P, Davies, ER, Lewis, JS, and Alexander, CM. The effect of kinesiotape on function, pain, and motoneuronal excitability in healthy people and people with Achilles tendinopathy. *Clin J Sport Med* 20: 416–421, 2010.
8. González-Iglesias, J, Fernández-de-Las-Peñas, C, Cleland, JA, Huijbregts, P, and Gutiérrez-Vega, MR. Short-term effects of cervical kinesio taping on pain and cervical range of motion in patients with acute whiplash injury: A randomized clinical trial. *J Orthop Sports Phys Ther* 39: 515–521, 2009.
9. Gribble, PA and Hertel, J. Considerations for normalizing measures of the star excursion balance test. *Meas Phys Educ Exerc Sci* 7: 89–100, 2003.
10. Hertel, J, Braham, RA, Hale, SA, and Olmsted-Kramer, LC. Simplifying the star excursion balance test: Analyses of subjects with and without chronic ankle instability. *J Orthop Sports Phys Ther* 36: 131–137, 2006.
11. Hubbard, TJ and Cordova, M. Effect of ankle taping on mechanical laxity in chronic ankle instability. *Foot Ankle Int* 31: 499–504, 2010.
12. Kase, K, Wallis, J, and Kase, T. *Clinical Therapeutic Applications of the Kinesio Taping Method* (2nd ed.). Tokyo, Japan: Ken Ikai Co Ltd, 2003.
13. Lees, A, Vanrenterghem, J, and De Clercq, D. The maximal and submaximal vertical jump: Implications for strength and conditioning. *J Strength Cond Res* 18: 787–791, 2004.
14. Lins, CA, Neto, FL, Amorim, ABC, Macedo, LB, and Brasileiro, JS. Kinesio Taping® does not alter neuromuscular performance of femoral quadriceps or lower limb function in healthy subjects: Randomized, blind, controlled, clinical trial. *Man Ther*, 18: 41–45, 2013.
15. Machin, D, Campbell, M, Fayers, P, and Pinol, A. *Sample Size Tables for Clinical Studies* (2nd ed.). Oxford, UK: Blackwell Science, 1997.
16. Meylan, C, McMaster, T, Cronin, J, Mohammad, NI, Rogers, C, and Deklerk, M. Single-leg lateral, horizontal, and vertical jump assessment: Reliability, interrelationships, and ability to predict sprint and change-of-direction performance. *J Strength Cond Res* 23: 1140–1147, 2009.
17. Sekir, U, Yildiz, Y, Hazneci, B, Ors, F, and Aydin, T. Effect of isokinetic training on strength, functionality and proprioception in athletes with functional ankle instability. *Knee Surg Sports Traumatol Arthrosc* 15: 654–664, 2007.
18. Słupik, A, Dwornik, M, Białoszewski, D, and Zych, E. Effect of Kinesio Taping on bioelectrical activity of vastus medialis muscle. Preliminary report. *Ortop Traumatol Rehabil* 9: 644–651, 2007.
19. Thelen, MD, Dauber, JA, and Stoneman, PD. The clinical efficacy of kinesio tape for shoulder pain: A randomized, double-blinded, clinical trial. *J Orthop Sports Phys Ther* 38: 389–395, 2008.
20. Vithoulka, I, Beneka, A, Malliou, P, Aggelousis, N, Karatsolis, K, and Diamantopoulos, K. The effects of Kinesio-taping on quadriceps strength during isokinetic exercise in healthy non athlete women. *Isokinetics Exerc Sci* 18: 1–6, 2010.
21. Wilmore, JH, Costill, DL, and Kenney, WL. *Physiology of Sport and Exercise* (4th ed.). Champaign, IL: Human Kinetics, 2008.
22. Wu, Y-K, Lien, Y-H, Lin, K-H, Shih, TT-F, Wang, T-G, and Wang, H-K. Relationships between three potentiation effects of plyometric training and performance. *Scand J Med Sci Sports* 20: 80–86, 2010.
23. Yoshida, A and Kahanov, L. The effect of kinesio taping on lower trunk range of motions. *Res Sports Med* 15: 103–112, 2007.