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# Kinesio Taping and the Circulation and Endurance Ratio of the Gastrocnemius Muscle

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***Context:*** Kinesio Tex tape is a therapeutic tape that is applied with the Kinesio-taping (KT) method and is theorized to increase circulation and subsequently improve muscle function. However, little research has been conducted to determine how KT affects performance.

***Objective:*** To determine the effect of KT on muscular endurance ratio, blood flow, circumference, and volume of the gastrocnemius muscle.

***Design:*** Randomized controlled clinical trial.

***Setting:*** Research laboratory.

***Patients or Other Participants:*** Sixty-one healthy, active people (23 men, 38 women; age = 19.99 ± 8.01 years, height = 169.42 ± 23.62 cm, mass = 71.53 ± 36.77 kg) volunteered to participate. They were assigned randomly to 1 of 3 groups: treatment KT, sham KT, and control.

***Intervention(s):*** Tape was applied based on group assignment. The treatment KT group received the ankle-tape technique as described in the KT manual. The sham KT group received 1 strip of Kinesio Tex tape around the circumference of the proximal gastrocnemius muscle. The control group did not receive tape application.

***Main Outcome Measure(s):*** The dependent variables were blood flow in blood perfusion units, volume of water displacement in milliliters, circumference of the gastrocnemius muscle in centimeters, and endurance ratio in joules measured before, 24 hours after, and 72 hours after the intervention. Separate repeated-measures analyses of variance were conducted for each dependent variable.

***Results:*** We found no group-by-test day interaction for endurance ratios ($F_{4,116} = 1.99$, $P = .10$). Blood flow, circumference, and volume measurements also yielded no differences among groups ($F_{2,58}$ range, 0.02–0.51; $P > .05$) or test days ($F_{2,116}$ range, 0.05–2.33; $P > .05$).

***Conclusions:*** We found KT does not enhance anaerobic muscle function measured by endurance ratio. The KT also did not affect circulation or volume of the gastrocnemius muscle in a healthy population.

***Key Words:*** calf, dynamometer, isokinetic exercises

**Key Points**

- Kinesio taping did not enhance muscle performance in a healthy adult population.
- Kinesio taping did not affect blood circulation, circumference, volume, or endurance of the gastrocnemius muscle.

The use of the Kinesio-taping (KT) method as a supplemental treatment in orthopaedic and sports medicine settings has increased. This method involves specific application of Kinesio Tex tape (Kinesio, Albuquerque, NM). The cotton, latex-free, adhesive, elastic Kinesio Tex tape is more porous and water resistant than standard athletic tape, allowing patients to wear it for 3 to 5 days after application.[1] Medical doctors, occupational therapists, physical therapists, chiropractors, and certified athletic trainers have used this taping method when treating orthopaedic injuries, but limited research has been conducted to evaluate the effectiveness. To date, researchers have evaluated range of motion (ROM),[2] pain,[3] quadriceps muscle peak torque,[4] functional hand and arm skills,[5] and proprioception.[6] However, the results of these studies on the therapeutic, rehabilitative, and physiologic effects of the KT method have been inconsistent. Some researchers have indicated that KT positively affects ROM, pain, peak torque, and functional hand and upper extremity skills,[2–5] whereas others investigating proprioception and peak torque found no improvements after tape application.[6,7] Therefore, further research on KT is warranted.

Kinesio taping has been theorized to lift the skin from the underlying fascia, increasing blood and lymphatic flow,[1] which might result in increased oxygen allotment to the muscle, decreased inflammation, and improved anaerobic muscle function.[8–10] To date, authors of only 2 studies have examined the effects of KT on muscle function. Slupik et al[4] used peak torque as the dependent variable. Fu et al[7] used both peak torque and total work. The results of these 2 studies were contradictory. After the application of Kinesio Tex tape, Slupik et al[4] found an increase in isometric peak torque in the vastus medialis muscle, whereas Fu et al[7] found no improvement in either isokinetic peak torque or total work of the quadriceps muscle. Their results might have differed for several reasons. First, they tested different muscles. Second, isometric peak torque was measured in one study,[4] and isokinetic peak torque was measured in the other.[7] Whereas aspects of these studies were different, both groups of researchers examined the effect this taping method had on anaerobic muscle function.[4,7] An alternative way to evaluate anaerobic muscle performance is by measuring the endurance ratio of a given muscle.[11–15] Endurance ratio can be altered by the amount of oxygen

**Table 1. Demographic Characteristics (Mean ± SD)**

| Group | Age, y | Height, cm | Mass, kg | Sex | |
|---|---|---|---|---|---|
| | | | | Male | Female |
| Control | 21.5 ± 3.5 | 165.7 ± 17.2 | 69.1 ± 10.2 | 10 | 10 |
| Sham Kinesio taping | 23.0 ± 5.0 | 172.1 ± 12.1 | 78.4 ± 22.0 | 7 | 13 |
| Treatment Kinesio taping | 21.0 ± 3.0 | 174.0 ± 19.1 | 75.2 ± 25.0 | 6 | 15 |

supplied to that muscle.[9,10] It is related to anaerobic energy stores in the muscle, energy supply pathways, local circulatory volume, and efficiency.[16] Theoretically, if KT enhances oxygen allotment via increased blood flow, the ability of the muscle to more rapidly perform oxidative metabolism would improve and subsequently would lead to better function of the muscle.[8–10,17]

Improved blood flow and strength also might affect muscle circumference and volume.[18] Volumetric measurements commonly have been conducted to evaluate the amount of edema present in a limb.[19–22] However, volumetric and circumference measurements of the leg also have been conducted as a representation of muscle mass and function.[23,24] Athletes with greater volume measurements have been identified as having increased muscle power and strength.[23]

If KT could reduce pain, increase ROM, and facilitate muscle contraction, it could be useful for rehabilitating injured muscles and improving performance. Therefore, the primary purpose of our study was to determine the effect of KT on the endurance ratio of the gastrocnemius muscle. Our secondary purposes were to evaluate the effect of KT on blood flow, circumference, and volume measures of the gastrocnemius and to evaluate if the way the Kinesio Tex tape was applied to the same area elicited a different outcome on muscle performance.

## METHODS

### Participants

Sixty-one healthy, active people (23 men, 38 women; age = 19.99 ± 8.01 years, height = 169.42 ± 23.62 cm, mass = 71.53 ± 36.77 kg) volunteered to participate in this study. People were included if they had no history of leg trauma within the year before the study. We considered the volunteers to be *healthy* and *active* if they exercised a minimum of 3 days each week for 30 consecutive minutes per day. *Leg trauma* was defined as injury to the knee or the ankle. People who had diabetes or were smokers were excluded from the study because these conditions can negatively affect peripheral circulation. All participants provided written informed consent, and the study was approved by the Institutional Review Board for the Protection of Human Subjects at Indiana University.

### Procedures

Participants were assigned randomly to the treatment KT, sham KT, or control groups using a random number generator (Table 1). All volunteers participated in 4 days of testing. The initial meeting day was used to complete paperwork and allow the participants to become familiar with the isokinetic dynamometer. After the initial meeting day, they did not participate in physical activity until the conclusion of the study. The following day (day 1) consisted of baseline measurements of blood flow, circumference, volumetric water displacement, and endurance ratio for the right leg. Participants received the treatment KT, the sham KT, or no tape. All Kinesio Tex tape applications were performed by the same certified Kinesio-Taping method practitioner (H.L.S.). Blood flow, circumference, volumetric water displacement, and endurance ratio testing were repeated at 24 hours (day 2) and 72 hours (day 3) after this intervention.

**Blood Flow.** Blood flow was measured for 5 minutes at the beginning of each test day using a noninvasive laser Doppler (LDF 100C; Biopac Systems, Inc, Goleta, CA). Laser Doppler flowmetry has been used to measure blood flow in tissue, but no research on the validity and reliability of this device has been published.[25–29] The laser Doppler includes a probe that emits infrared light into the tissue and specifically measures blood perfusion units (BPUs) and percentage of backscatter. *Blood perfusion units* are defined as the number of moving blood cells in the area measured multiplied by the velocity of those blood cells. *Percentage of backscatter* is the amount of infrared light that is reflected back to the probe by red blood cells during the time of measurement. Participants were instructed to lie prone on the testing table and remain still during the test time. The laser Doppler probe was secured on the skin 5 in (12.7 cm) below the popliteal fossa. To ensure consistent placement of the laser Doppler probe throughout the 3 test days, we drew a crosshair design around the targeted area that remained on the skin for the duration of the testing days (Figure 1). We used AcqKnowledge software (version 3.7.3; Biopac Systems, Inc) to record and store the blood flow data. The BPU and percentage of backscatter data

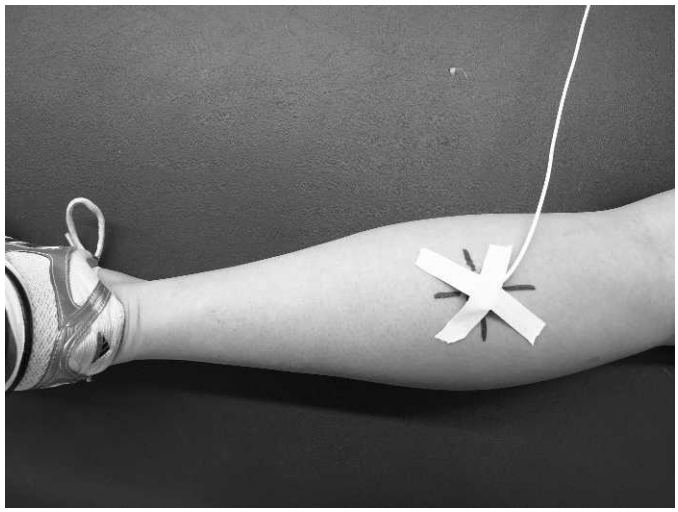

**Figure 1. Crosshair design and positioning for laser Doppler probe (LDF 100C; Biopac Systems, Inc, Goleta, CA).**

**Figure 2. Circumference measurement markings.**

were collected for 5 minutes, and the average of each was used for statistical analysis.

**Circumference and Volume.** Two measures of muscle volume were collected. The same clinician (H.L.S.) tested each participant's circumference in centimeters at 4-cm increments, starting at the base of the medial and lateral malleoli and ending at the head of the fibula (Figure 2). Researchers have shown that circumference measurements taken with a spring measuring tape are reliable (intraclass correlation coefficient = 0.99 for the maximum circumference of the calf).[30] Therefore, the maximum circumference of the gastrocnemius of each participant was used for statistical analysis.

Volumetric water displacement in milliliters was measured after circumferential measurements were recorded. Researchers have shown that volumetric water displacement is reliable (intraclass correlation coefficient = 0.97).[31] For our study, we followed the procedures of Pasley and O'Connor.[31] A 24.5-in- (62.23-cm)-tall volumeter (Sammons Preston, Bolingbrook, IL) was filled with tepid water until it overflowed into a container placed under the spout. Next, the container was removed, and a dry container was placed under the spout of the volumeter. Participants inserted their right feet into the volumeter until the balls of their feet touched the bottom of the tank. We instructed them not to place their feet flat on the bottom of the tank because the variation in foot pressure might change water displacement.[31] Next, we instructed them to hold the balls of their feet in that position without moving until the water stopped flowing out of the volumeter (Figure 3). Displaced water was collected in the container under the spout of the volumeter and measured.

**Endurance Ratio.** Total work of the gastrocnemius muscle was measured with a CYBEX NORM dynamometer

**Figure 3. Volumetric water displacement procedure.**

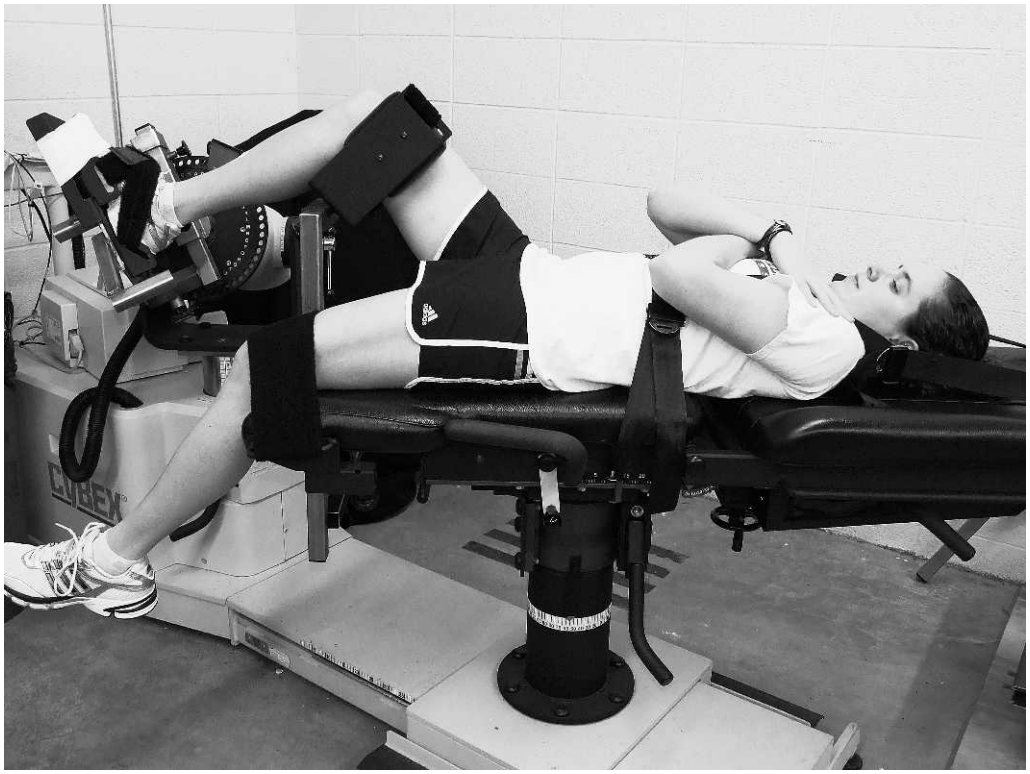


**Figure 4. CYBEX NORM (CYBEX International, Inc, Ronkonkoma, NY) patient positioning.**

(CYBEX International, Inc, Ronkonkoma, NY; Figure 4). Researchers have shown that the dynamometer is a reliable measure of isokinetic muscle strength at 120°/s ($r = 0.82$)[11] and at 60°/s, 120°/s, and 180°/s ($r = 0.90$).[32] The CYBEX NORM isokinetic dynamometer is a self-calibrating device. Participants were positioned supine with their right legs secured into the thigh stabilizer and their right feet secured to the foot plate. The thigh stabilizer was adjusted so that their knees were in 90° of flexion. The input-arm penetration and foot-plate penetration were set so that the ankle axis of rotation was in line with the axis of the dynamometer. Each participant's ROM then was assessed. Mechanical ROM stops were positioned according to each participant's end ROMs. Each participant's specific ROM was used for all subsequent test days. The velocity of the CYBEX NORM was set at 180°/s. Next, we recorded the position markings. After setup procedures were concluded, participants performed 1 set of 30 concentric plantarflexion and dorsiflexion repetitions with their right legs. Total work data were collected. Endurance ratio in joules was calculated automatically by the CYBEX NORM by dividing the total work of the last 15 repetitions by the total work of the first 15 repetitions and multiplying by 100.[16]

**Taping.** At the completion of testing on day 1, tape or no tape was applied depending on group assignment. Before tape application, we cleaned the skin with an alcohol preparation pad and sprayed the skin with tape adherent (Tuf-Skin; Cramer Products, Inc, Gardner, KS). Tape was applied to the right leg of the participant. The treatment KT group had Kinesio Tex tape applied over the gastrocnemius muscle according to the KT manual[33] (Figure 5A). The participant was positioned prone on a table with the foot dorsiflexed so the skin was stretched. Two strips of tape were applied to the proximal origin of the muscle, with 1 strip framing the gastrocnemius medially and 1 framing it laterally. The tape ran the length of the muscle and ended at the distal insertion on the calcaneus. The sham KT group had a sham, or placebo, tape technique applied. Participants stood on the table with their feet in neutral position, and 1 strip of Kinesio Tex tape was placed around the circumference of the leg, encompassing the gastrocnemius (Figure 5B). A blow dryer was used over the area for 60 seconds to speed up the heat-activated adhesion process for both tape groups. Participants were instructed not to remove the tape. Participants in the control group did not receive any tape application. All participants were reminded to refrain from lower body exercise with the exception of activities of daily living for the duration of the study.

### Statistical Analysis

Separate mixed, repeated-measures analyses of variance (ANOVAs) with 1 within-subject factor (day at 3 levels: day 1, day 2, day 3) and 1 between-subjects factor (group at 3 levels: treatment KT, sham KT, and control) were conducted to determine differences among the groups and test days for each dependent variable. The $\alpha$ level was set a priori at .05.

## RESULTS

The ANOVA for endurance ratio indicated no group-by-test day interaction ($F_{4,116} = 1.99$, $P = .10$, effect size = 0.06, power = .58; Figure 6). In addition, we did not identify a difference among groups ($F_{2,58} = 2.61$, $P = .08$, effect size = 0.08, power = .50) or test days ($F_{2,116} = 2.22$, $P = .11$, effect size = 0.04, power = .45). Similarly, the blood flow, circumference measurements, and volumetric water


**Figure 5. A, Treatment Kinesio Taping on gastrocnemius. B, Sham Kinesio Taping on gastrocnemius.**

displacement yielded no differences among the treatment, sham, or control groups ($F_{2,58}$ range, 0.02–0.51; $P > .05$) or among test days ($F_{2,116}$ range, 0.05–2.33; $P > .05$). Means and standard deviations for all variables are provided in Table 2.

## DISCUSSION

We found that KT had no effect on the endurance ratio of the gastrocnemius muscle. We also found that KT had no effect on circulation to the muscle, as measured by blood flow, circumference, and volumetric water displacement. These results were the same in both the treatment KT group and the sham KT group.

We evaluated these variables because KT is theorized to create convolutions in the skin and thus increase circulation and lymphatic flow to the taped area.[33] The purported increase in blood and lymphatic flow potentially could affect volume by decreasing inflammation and subsequently could increase anaerobic performance of the muscle.[8–10,17] Our results do not support this theory in healthy athletes. However, KT might increase anaerobic metabolism in injured athletes. Although we found KT did not increase circulation or muscle performance, it still might positively

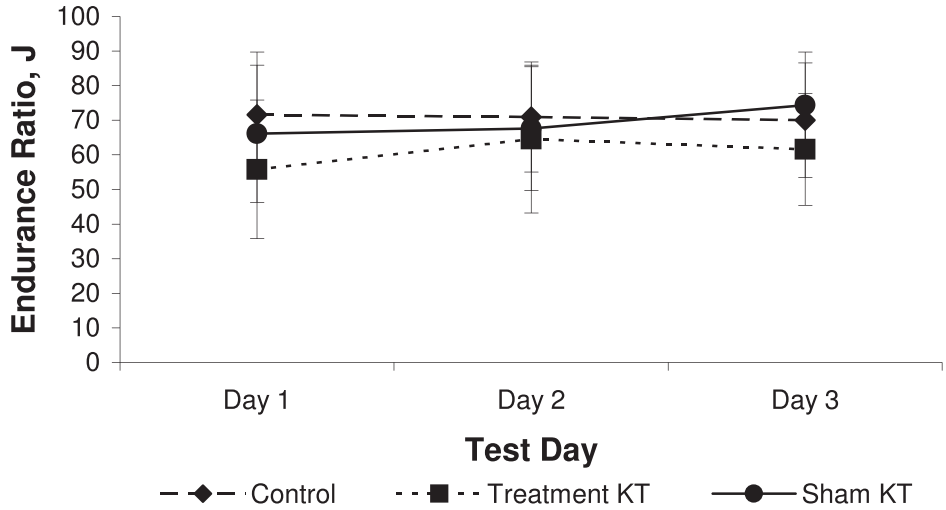


**Figure 6. Endurance ratio with means and standard deviations (N = 61). Abbreviation: KT, Kinesio Taping.**

**Table 2. All Dependent Variables (Mean ± SD) (N = 61)**

| Variable | Test Time | | |
|---|---|---|---|
| | Day 1 (Baseline) | Day 2 (24 h) | Day 3 (72 h) |
| Endurance ratio, J | | | |
| Control | 71.60 ± 18.10 | 70.95 ± 15.91 | 70.03 ± 16.55 |
| Treatment Kinesio taping | 55.82 ± 20.04 | 64.56 ± 21.37 | 61.62 ± 16.16 |
| Sham Kinesio taping | 66.12 ± 19.86 | 67.61 ± 17.89 | 74.33 ± 15.36 |
| Blood flow, blood perfusion units | | | |
| Control | 36.62 ± 6.61 | 39.96 ± 10.78 | 34.88 ± 5.80 |
| Treatment Kinesio taping | 37.51 ± 7.61 | 38.90 ± 11.67 | 37.09 ± 11.87 |
| Sham Kinesio taping | 36.99 ± 8.95 | 35.14 ± 9.02 | 35.43 ± 5.92 |
| Backscatter, % | | | |
| Control | 48.71 ± 10.92 | 51.41 ± 10.49 | 49.89 ± 10.07 |
| Treatment Kinesio taping | 51.98 ± 9.47 | 48.66 ± 8.51 | 50.73 ± 10.97 |
| Sham Kinesio taping | 49.50 ± 13.13 | 49.35 ± 11.65 | 48.32 ± 9.64 |
| Circumference, cm | | | |
| Control | 36.33 ± 2.13 | 36.43 ± 2.08 | 36.46 ± 2.07 |
| Treatment Kinesio taping | 36.36 ± 2.84 | 36.56 ± 2.84 | 36.53 ± 2.84 |
| Sham Kinesio taping | 36.59 ± 3.33 | 36.58 ± 3.33 | 36.54 ± 3.27 |
| Volumetric water displacement, mL | | | |
| Control | 3683.50 ± 404.86 | 3683.50 ± 386.10 | 3670.75 ± 392.89 |
| Treatment Kinesio taping | 3707.14 ± 468.69 | 3691.43 ± 437.36 | 3702.86 ± 461.82 |
| Sham Kinesio taping | 3671.75 ± 551.67 | 3671.75 ± 571.99 | 3688.25 ± 541.87 |

affect other areas. In addition, Kase et al[33] described many different taping techniques that still warrant research and might be beneficial to our athletes. Lastly, how KT affects patients with acute injuries is a topic that still has not been researched fully.

## KT Applications

The manufacturers of Kinesio Tex tape state that if the tape is applied in specific ways, it can facilitate an increase in circulation.[33] This increase subsequently might lead to increased function as more oxygen is delivered to the muscle. Based on this claim, participants in both the treatment KT and sham KT groups should have demonstrated increased muscle performance. In addition, one might hypothesize that the treatment KT group should have shown the greater increase because a certified technician using the proper technique applied the tape. The technique entails applying the tape while it is being stretched and is theorized to subsequently aid in muscular contractions.[33] However, our data did not support this theory. We found that neither of the KT groups demonstrated a change in anaerobic muscular performance. This finding is in agreement with findings of other researchers[7] who have evaluated muscle function using peak torque and total work and also have identified no improvement in strength with KT. Based on our findings, we concluded that whereas these measures were repeatable over 3 test days, neither of the Kinesio Tex tape applications affected any of the variables we evaluated. Although this application was not beneficial in healthy participants, it might positively affect acute injuries if applied with the proper technique.

## Muscle Performance

Examination of muscle performance was warranted because authors of only 2 studies[4,7] have evaluated anaerobic muscle performance. Whereas the endurance ratio of a muscle was not measured in either study, the methods of the investigators influenced our decision about the length of time to leave the Kinesio Tex tape applied to the participants. The results of the study by Fu et al[7] suggested that KT does not affect either peak torque or total work of the quadriceps muscle after being left on the skin for 12 hours. Slupik et al[4] studied the quadriceps muscles of 27 healthy persons and found an increase in the peak torque only after 24 hours of wearing Kinesio Tex tape.[4] From these 2 studies, we determined that if Kinesio Tex tape was to produce a difference, it would need to be left on for at least 24 hours. Therefore, we measured muscle performance before, 24 hours after, and 72 hours after tape application. However, regardless of the length of time Kinesio Tex tape was applied, we found no improvement in endurance ratio. Despite our results, we recommend that injured athletes treated with KT should wear the tape longer than 24 hours because it might offer benefits after that time.

## Muscle Volume

No one has directly measured the effect that KT has on circulation. However, investigators evaluating low back ROM have hypothesized that the improvement in ROM could have been caused by an increase in blood flow.[2] Therefore, we specifically examined the effect KT might have on blood flow using 3 quantitative measurements: blood flow as measured by a laser Doppler, circumference, and volumetric water displacement .

Increases in muscle volume also have been measured by circumference measurements or volumetric water displacement.[19] Investigators[18] have identified that improved blood circulation to the muscle resulted in increased muscle volume. A correlation between increased muscle volume and enhanced muscle function and muscle mass has been reported.[23] Improved circulation specifically has led to increased muscle volume, peak muscle power, and maximal

muscle activation measured by electromyography.[18,23] We were interested in learning if KT would increase or decrease the circumference and volume of the gastrocnemius muscle; however, the blood flow, circumference measures, and volume data supported our findings for endurance ratio because none of the measurements changed over the test days. Therefore, we can conclude that KT does not improve circulation in the gastrocnemius of a healthy individual.

### Limitations

A limitation of our study could have been the population tested. Studying only healthy individuals allowed us to control other variables and easily establish a baseline for measurement. However, a drawback from studying a healthy population is that the participants might not have impaired muscle endurance, so improving performance with the tape might be more difficult. Nevertheless, we believe this is an important first step based on the limited research on this topic. Finally, the laser Doppler that we used has not been described extensively in the literature, and no normative values have been established.

### Future Research

Because little research is available on the topic of KT, further investigation still needs to be conducted. Specifically, more studies should be conducted on the manufacturer's claim that KT causes an increase in circulation. No one has examined the effects that KT has at the cellular level. Future research should be conducted on the purported claim that changes in vascular and lymphatic flow occur with Kinesio Tex tape application. The KT method also is theorized to decrease inflammation. This was not an aim of our study because we included healthy participants, but investigators should evaluate the effect KT has on acute inflammation due to an injury and how this tape application can assist rehabilitation. Using a more advanced method of blood-flow measurement, such as an ultrasound or color Doppler, could be a more precise method of evaluating this effect without resorting to invasive techniques. Future research also should be conducted on injured individuals to ascertain if KT could affect muscle performance after an acute injury. A qualitative KT study conducted on athletic individuals in real-work settings also might help researchers understand differences in proper Kinesio Tex tape application versus a placebo application.

## CONCLUSIONS

Based on our results, we conclude that KT did not enhance muscle performance in a healthy population. We found KT did not affect blood circulation or volume of the gastrocnemius muscle. Using 2 different taping methods also did not elicit any changes in our dependent variables. Clinically, these results indicated that KT might not enhance muscle endurance in healthy athletes, but future researchers might find potential benefits for the injured individual.

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