

Kinesio Tape® Applied to the Thorax Augments Ventilatory Efficiency during Heavy Exercise

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ABSTRACT

International Journal of Exercise Science 6(2) : 157-163, 2013. Kinesio Tape® (KT) is purported to help coordinate involuntary contractions. KT applied to the thorax is believed to enhance breathing during constant-load exercise, but verification is lacking. We had 12 participants complete a graded exercise test to determine gas-exchange threshold (GET), and two, constant-load bouts sufficient in intensity to evoke the VO₂ slow component using no tape (NT) or KT applied to the thorax, respectively, in counterbalanced order. Indirect calorimetry measured ventilatory and gas-exchange parameters, and a 3-lead EKG recorded heart rate (HR). A greater expiratory tidal volume (+150 mL min⁻¹) along with a small, yet significant ($P < 0.05$), improvement in mechanical efficiency occurred when using KT. Using KT did not affect exercising respiratory rate or HR, and most participants reported that KT was comfortable during exercise. ATs may apply KT to the thorax to improve heavy exercise efficiency, but research on exhaustive exercise is warranted.

KEY WORDS: Mechanical efficiency, ventilation, VO₂ slow component

INTRODUCTION

Kinesio Tape® (KT), also known as Kinesio Tex Tape, was first conceived in 1973 (10), but its use was not prevalent until 1995 (11). In comparison to conventional taping, KT can be stretched to 140% of its original length, imparting elastic energy when released (10). A purported benefit for the elasticity of KT is to subconsciously augment neuromuscular coordination (11). Although KT has been evaluated using surface electromyography with stabilizing ankle (7) and shoulder (17) muscle actions with equivocal results, little has been reported on the thorax-taping technique. Athletic trainers (AT) receive formal and

clinical training in the application of prophylactic taping (1); thus, coaches and athletes alike regularly consult with ATs regarding the use and the application of KT.

The application of KT to the thorax was conceived to assist with expiratory ventilation (10). In brief, the KT is pulled peripherally across the natural inclination of the thorax (Figure 1). In this manner the elasticity of the KT would aid expiration and potentially aid those with expiratory disorders (11). Whether this application enhances the efficiency of the ventilatory muscles, to our knowledge, has not been investigated.

The influence of ventilatory cost on total exercising oxygen uptake (VO_2) during heavy exercise represents a viable means to explore the efficacy of the KT thorax technique. At exercise intensities above the gas exchange threshold (GET), it is well established that a slow rise in VO_2 occurs despite no change in power (6). This time-dependent decline in mechanical efficiency (ME), termed the VO_2 slow component (4), is attributed, in part (~11%), to a disproportionate increase in ventilation (16). Thus, if the KT thorax technique were effective, it would augment ME (i.e., the ventilatory muscles working more efficiently would require less metabolic energy therefore potentially improving aerobic performance). The purpose of this study was to test the hypothesis that KT would augment ME during heavy exercise.

METHODS

Participants

A convenience sample of six men and six women volunteered to engage in a graded-exercise test (GXT) and subsequent heavy-exercise bouts with and without KT applied to the thorax. A health-history questionnaire was administered to exclude participants with any respiratory problems and other health conditions that would preclude their safe participation. The demographic data for the participants are as follows: age 23 ± 2.5 years, height 175.0 ± 10.6 cm, mass 74.4 ± 12.9 kg, BMI 24.2 ± 2.6 kg/m^2 , and relative $\text{VO}_{2\text{max}}$ 36.98 ± 6.34 $\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. Participants self-reported their compliance with avoiding the consumption of food and beverages containing alcohol, non-prescription drugs, caffeine, or supplements, along with any strenuous exercise 24 hours prior to testing.

Written, informed consent was obtained, and all procedures were approved by the host university's institutional review board.

Protocol

Instrumentation: Data for the GXT and constant-load exercise bouts were gathered, on a breath-by-breath basis, using a calibrated metabolic analyzer (Parvo Medics TrueOne 2400, Salt Lake City, UT) and electrocardiograph (Quinton Q4500 Stress System, AVI Medical, San Diego, CA). Gas-exchange samples for all exercise trials were measured. Samples were saved at 15-second averages to allow for determining GET, whereas samples for the constant-load trials were saved at 1-minute averages. Following cleansing with isopropyl alcohol swabs and skin abrading, a limb-lead arrangement was applied to the deltopectoral triangles and lateral 10th ribs. Such an arrangement permitted the monitoring of the heart rate, on a continuous basis, without obstructing the KT application.

All exercise bouts were conducted on a cycle ergometer with an electronically braked flywheel (Lode Excaliber Sport, Groningen, The Netherlands). The saddle height, handle bar placement, and cadence were similar for the GXT and constant-load exercise trials for each participant respectively. Cycling, as opposed to treadmill walking, was selected because of the increased likelihood entraining breathing with the motions of the extremities (2). Moreover, cycling, in comparison to running, evokes a more pronounced VO_2 slow component (9), thus enabling us to better explore any potential effects of the KT on ME and ventilation.

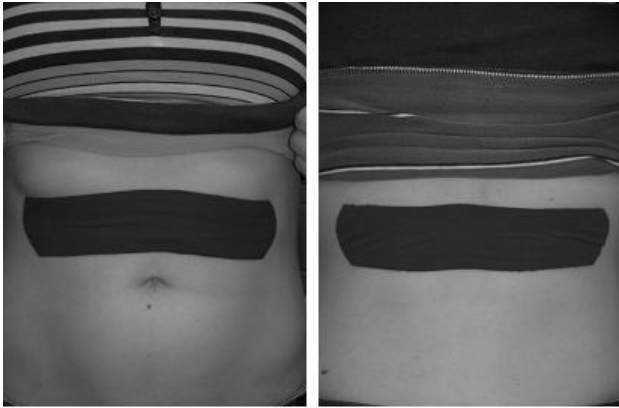


Figure 1. Application of Kinesio Tape® to the thorax. KT was applied starting in the center of the abdomen, 2 cm below the xyphoid process while the participant inhaled to reach the maximal rib cage expansion (Left Panel). The center of the tape was adhered first and then the rest of the tape was affixed with adding stretch. Another second KT strip was applied to the participants' backs (same level) while the participants leaned over a table, flexing their hips and extending their lumbar spines (Right Panel).

Constant-Load Exercise Bouts: The participants returned to the laboratory on a different day to perform two separate, 6-minute bouts of constant-load cycling at identical, heavy-exercise intensities. The heavy intensity was set at $\Delta 30\%$, i.e., $W_{GET} + [0.3 (W_{peak} - W_{GET})]$, a sufficient intensity to evoke a VO_2 slow component while not exceeding critical power (N.B., $>\Delta 40\%$) and causing early fatigue (3). Twenty minutes of recovery were provided between bouts, and cycling cadence was similar to that selected for the GXT. In a counter-balanced order, the participants exercised with either no tape (NT) or with KT applied to their thoraxes (Figure 1). The KT was applied to clean, dry skin at least 10 minutes prior to exercise to promote adhesion and to allow participants to adjust to the feel of the tape on their skin. The same clinician, trained by a KT-certified, licensed physical therapist, administered the KT thorax application for all participants of this study.

Expired data from the constant-load exercise bouts were saved at single-minute averages, whereby the expired data during the last minute of exercise were evaluated. Expired VO_2 and carbon dioxide (VCO_2) along with cycling power were used to determine ME, as derived using:

$$ME (\%) = \frac{\text{Mechanical Energy [Power (W)*69.767 (Kcal min}^{-1} \cdot \text{W}^{-1})]}{\text{Metabolic Energy [Kcal min}^{-1}]}$$

Where 69.767 represents the conversion of mechanical work to metabolic units, and the denominator used the expired VO_2 and VCO_2 data, with the following equations (13) to derive metabolic energy using:

$$\text{Energy} = \text{Carbohydrate (3.8683 Kcal gm}^{-1}) + \text{Fat (9.7460 Kcal gm}^{-1})(\text{Kcal min}^{-1})$$

where:

$$\begin{aligned} \text{Carbohydrate Utilization (gm}\cdot\text{min}^{-1}) &= [4.585 (VCO_2) - 3.226 (VO_2)] \text{ and} \\ \text{Fat Utilization (gm}\cdot\text{min}^{-1}) &= [1.695 (VO_2) - 1.701 (VCO_2)]. \end{aligned}$$

As such, the computation of ME accounts for how an intervention potentially affects total VO_2 cost along with substrate utilization. Specifically, an improvement in ME would result in a reduction in exercising VO_2 along with a reduced reliance on oxidizing carbohydrates to meet ATP demands (i.e., lower Kcal per liter of oxygen) (14).

Self-Report Questionnaire: The participants were asked to complete a two-item questionnaire after the constant-load bout during which KT was applied (prior to its removal). In a Likert-type format, ranging from 1 = 'strongly disagree' to 5 'strongly agree,' the participants responded

to the following item: “The tape was comfortable on my skin.” A second, open-ended item asked the participants to describe how they perceived the tape applied to their skin during the exercise bout.

Statistical Analysis

A series of paired-t tests were used to determine if KT affected the physiological measures of ME, expired ventilatory tidal volume, respiratory rate, and exercising heart rate. Alpha was set at $P < .05$ for all tests. The frequencies are reported for the Likert-type item on comfort, whereas the open-ended responses are described in a narrative summary.

RESULTS

As illustrated in Figure 2, the constant-load exercise bouts were sufficient to evoke a VO_2 slow component, as evidenced by the lack of steady-state attainment between the 3rd and 6th minutes of exercise (4). Whole-body ME was higher in the KT vs. the NT condition, whereas expired tidal volume was higher (Table 1). KT application had no effect on respiratory rate or heart rate ($P > 0.05$).

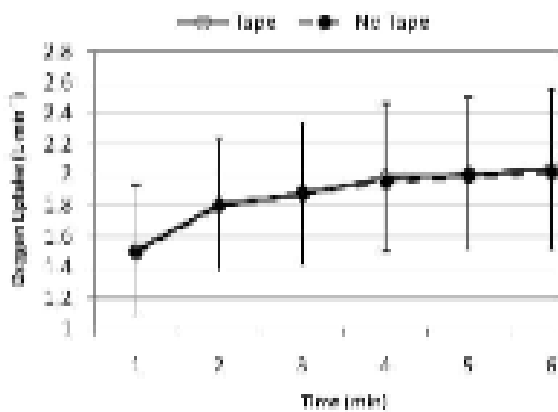


Figure 2. Oxygen uptake (Mean ± Standard Deviation) during heavy exercise with and without Kinesio Tape® applied to the thorax.

Table 1. Heavy exercise responses (Mean ± Standard Deviation) with and without Kinesio Tape® applied to the thorax.

Variable	No Tape	Kinesio Tape®	t value	P
Mechanical Efficiency (%)	20.50 ± 9.95	20.78 ± 9.79	2.34	0.04*
Heart Rate (bpm)	165.17 ± 15.36	164.75 ± 16.83	0.40	0.70
Respiratory Rate (bpm)	28.11 ± 6.53	27.22 ± 7.46	1.70	0.12
Expired Tidal Volume (mL min⁻¹)	2170 ± 0.410	2320 ± 0.590	2.27	0.04*

*Significant ($P < 0.05$) difference on the paired-t test.

According to the KT questionnaire, 11 of the 12 participants “agreed” or “strongly agreed” that KT was comfortable on the skin, whereas one participant was “neutral.” For the open-ended item, 10 of 12 participants were ambivalent regarding the KT application. For example, they responded they “could not feel it,” “forgot about it,” or “didn’t notice it.” One subject replied that KT would be analogous to “wearing a BAND-AID®.”

DISCUSSION

The primary findings of this study were that KT applied to the thorax enhanced ME and increased expiratory tidal volume, without a concomitant effect on respiratory rate or heart rate (Table 1). The KT did not appear to affect ventilation on a voluntary basis; rather, many participants self-reported that the KT went “unnoticed” during the heavy-exercise bout. Thus, our data suggest that ATs may apply KT to the thorax to augment expiration without the participants being aware of it.

As indicated earlier, heavy exercise is characterized by the appearance of a VO_2 slow component (4, 6). Although a large portion of this time-dependent rise in VO_2 is attributed to the exercising muscles (e.g., recruitment of type II fibers), a small portion of this reduction in ME is attributed to ventilation (~11%) (16). Specifically, at higher intensities, the disproportionate work of ventilating causes added energy expenditure. As it is unlikely that KT applied to the thorax affected the leg muscles during the cycle ergometry bout, we attribute our ME results to the benefits of the tape elasticity on aiding expiration during heavy exercise.

As shown in Table 1, KT applied to the thorax evoked an increase in expiratory tidal volume (+150 mL min^{-1}). Such an increase in ventilation occurred without causing additional oxygen uptake (Figure 2). At rest, expiration is accomplished by simply relaxing the thorax; however, during heavy exercise, the chest-wall muscles contract actively to aid with developing intrapleural pressure (8). As such, ventilatory muscles (8), and subsequently the VO_2 slow component (4), contribute to exercise fatigue. Because we did not collect electromyographic data, we cannot conclude the precise cause for the improved ME we observed. The KT may have reduced the contractile burden on the ventilatory muscles or it may have reduced the pressure against which the chest muscles had to work. Electromyography or transdiaphragm pressures, or both, would be necessary to definitively resolve this research question.

We acknowledge that the observed improvement in ME (Table 1), although statistically significant, could be deemed as

marginal, in statistical effect size. The extrapolated calculation on ME in this study was to the minute average. Therefore, any marginal benefit in ventilatory efficiency would compound itself with each passing minute of exercise (i.e., ~150 to 160 chest-wall contractions occurred for the entire 6-minute exercise bout). Thus, the more pressing question centers on the relevance of our results: that is, why would a marginal, putative effect on ventilatory efficiency translate to improved aerobic performance?

The answer to the aforementioned question centers on recent advances regarding the roles of ventilation and of fatigue. Traditional views on the determinants of aerobic metabolism favor factors related to peripheral determinants (e.g., mitochondrial enzyme content) (18). Tolerance (duration) to a graded-exercise test or a constant-load exercise bout has been attributed to a 'Central Governor Model' (12); however, Dempsey et al (5) summarized a series of studies that bring the role of ventilatory muscles on mediating dynamic exercise intolerance to the forefront. In their fatigue model, strain on the chest-wall muscles initiates a cascade of events, culminating with a metaboreflex that constricts blood flow to the exercising limbs, presumably as a protective effect. Thus, small, putative effects of KT on ventilatory efficiency may delay a series of physiological events linked with fatigue.

Kase (11) suggested that KT may be used as a long-term prophylactic (e.g., applied for several days). The thorax application might fit as one of those long-term applications; however, our study was confined to comparing 6-minute, heavy-exercise bouts. What remains unclear is the duration for

the elasticity of the KT applied to the thorax and whether the benefits on ME are long lasting. As such, our comments on the viability of KT applied to the thorax for enhancing longer exercise durations is speculative, and more research is needed. Since the participants in the current study did not reach volitional fatigue on the constant-load exercise bouts, a study of the effect of KT on time to volitional fatigue during severe exercise may be warranted.

The application of KT has been posited to enhance involuntary muscular contractions (11). We compared healthy individuals engaged in 6-minute, heavy-exercise bouts, with and without the application of KT to the thorax. Our findings lead us to conclude that KT application can augment ventilatory efficiency by aiding expiratory tidal volume.

KT is a relatively new taping application (11). Since ATs are educated formally on prophylactic taping (1), and are frequently seen applying tape, ATs naturally represent the professional often consulted on the use and the application of KT. Although the thorax technique for KT is relatively understudied, our data indicate this specific technique offers promise. We remind the reader, however, that further research on the KT application to the thorax using longer exercise durations is recommended before widespread recommendations can be made.

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