



Acute effect of elastic bandage technique on middle deltoid muscle force and activation in healthy men

Efeito agudo da técnica de bandagem elástica sobre a força e ativação muscular do deltoide médio em homens saudáveis

Efecto agudo de la técnica de bandaje elástica sobre la fuerza y activación muscular del deltóide medio en hombres sanos

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Abstract

Introduction: Elastic bandages (EB), such as Kinesio taping, have been widely used in sports or daily life activities with the aim of preventing or reducing musculoskeletal injuries. It has been suggested that Kinesio Taping is capable of altering muscle activation through neurophysiological mechanisms, but the evidences about this are controversial. **Objective:** To verify the acute effect of EB on maximum voluntary isometric force (MVIF) and muscle activation of the middle deltoid muscle during muscle contraction. **Method:** Twenty-four healthy male (24 ± 4 years, 73.2 ± 13.9 kg, 1.80 ± 0.10 m) were randomly assigned to a group with elastic bandage activated at 100% (AEB n = 8); with tensionless elastic bandage (NEB n = 8), and the control group (CG n = 9). The volunteers were instructed to perform 5s of maximal isometric contraction at 90° of shoulder abduction while the MVIF and EMG_{rms} records were registered. **Results:**

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One-way ANOVA was unable to identify significant difference ($\alpha = 0.05$) in MIVF and EMG_{rms} of the middle deltoid at 90° of shoulder abduction. **Conclusion:** The application of elastic bandage was not able to alter the production of maximal isometric voluntary contraction and activation of the middle deltoid muscle of healthy individuals and, therefore, its use is not justified for these purposes.

Keywords: Muscle Force. Electromyography. Athletic Tape.

Resumo

Introdução: Bandagens elásticas (BE), como a Kinesio taping, têm sido amplamente utilizadas em atividades esportivas ou da vida cotidiana com o objetivo de prevenir ou reduzir as lesões musculoesqueléticas. Tem sido sugerido que a Kinesio Taping é capaz de alterar a ativação muscular por meio de mecanismos neurofisiológicos, mas as evidências são controversas. **Objetivo:** verificar o efeito agudo da BE sobre a força isométrica voluntária máxima (FIVM) e ativação muscular do músculo deltoide médio durante a contração muscular. **Método:** Vinte e quatro participantes saudáveis, do sexo masculino (24 ± 4 anos; $73,2 \pm 13,9$ kg; $1,80 \pm 0,1$ m) foram distribuídos aleatoriamente em grupo com a bandagem elástica ativada a 100% (BEA $n = 8$) e com bandagem elástica sem tensão (BEN $n = 8$), ambas posicionadas no ombro; além do grupo controle (GC = 9). Os voluntários foram orientados a realizar 5s de contração isométrica máxima a 90° de abdução da articulação do ombro enquanto os registros de FIVM e EMGrms eram captados. **Resultados:** A ANOVA de uma entrada não foi capaz de identificar diferença significativa ($\alpha = 0,05$) na FIVM e na EMGrms do deltoide médio a 90° de abdução da articulação do ombro. **Conclusão:** A aplicação da bandagem elástica não foi capaz de alterar a produção da força isométrica voluntária máxima e a ativação do músculo deltoide médio de indivíduos saudáveis e, portanto, seu uso não se justifica para esses fins.

Palavras-chave: Força Muscular. Eletromiografia. Fita Atlética.

Resumen

Introducción: Vendaje elásticos (VE), como la Kinesio taping, han sido ampliamente utilizadas en actividades deportivas o de la vida cotidiana con el objetivo de prevenir o reducir las lesiones musculoesqueléticas. Se ha sugerido que la Kinesio Taping es capaz de alterar la activación muscular por medio de mecanismos neurofisiológicos, pero las evidencias son controvertidas. **Objetivo:** verificar el efecto agudo de los VE sobre la fuerza isométrica voluntaria máxima (FIVM) y activación muscular del músculo deltoide medio durante la contracción muscular. **Método:** Veinticuatro participantes sanos, del sexo masculino (24 ± 4 años, $73,2 \pm 13,9$ kg, $1,80 \pm 0,1$ m) fueron distribuidos aleatoriamente en grupo con el vendaje elástico activado al 100% (VEA $n = 8$); con el vendaje elástico sin tensión (VEN $n = 8$; y el grupo de control (GC = 9). Los voluntarios fueron orientados a realizar 5s de contracción isométrica máxima a 90° de abducción de la articulación del hombro mientras los registros de FIVM y EMGrms eran captados. **Resultados:** La ANOVA de una entrada no fue capaz de identificar diferencia significativa ($\alpha = 0,05$) en la FIVM y en la EMGrms del deltoide medio a 90° de abducción de la articulación del hombro. **Conclusión:** La aplicación de el vendaje elástico no fue capaz de alterar la producción de fuerza isométrica voluntaria máxima y la activación del músculo deltoide medio de individuos sanos y, por lo tanto, su uso no está justificado para esos propósitos.

Palabras clave: Fuerza Muscular. Electromiografía. Cinta Atlética.

Introduction

Kinesio taping (KT) is a non-invasive therapeutic technique that uses a tape, Elastic Bandage (EB), developed in Japan by the Japanese chiropractor Kenzo Kase in 1973 to imitate the qualities of human skin with the same thickness of the dermis.

The bandage used is thinner and more elastic than conventional tape, which, hypothetically, allows greater mobility and traction of the skin [1]. The technique combines tensioning along the tape and placing the target muscle in an elongated position so that the circumflexions in the tape occur after its application. According to its creator, this traction

promotes an elevation of the epidermis and reduces the pressure on the mechanoreceptors below the dermis, thus reducing nociceptive stimuli [2].

The technique has been indicated for reducing edema, improving stability and proprioception while performing movements, reducing pain intensity, joining realignment and changing recruitment activity patterns of treated muscles, and improving sports performance in sports injury rehabilitation and prevention protocols [2-11]. Although widely used in clinical practice by many physical therapists around the world, evidence is controversial or non-existent about the effectiveness of this intervention. Indeed, from 2017 onwards, it is possible to find numerous systematic reviews and meta-analyses of the KT effects on several variables, and the overwhelming majority of these does not support the claims of its creator [12-15].

Despite the very high number of publications on the effects of KT on numerous variables and under various conditions, little is known about its influence on activity patterns and muscle recruitment. Surface electromyography (SEMG) is the most conventional method used to record electrical firing and variations in muscle activation (EMG_{rms}) during contraction and is useful for checking the level of coordination or imbalance of different muscles, the degree and duration of muscle activity, fatigue rates, and how Motor Units (MU) behave during muscle action [16].

Several methodological aspects interfere in the analysis of EMGS data. These include: individual anatomy (subcutaneous tissue thickness), detection system (electrode location over muscle), physical (tissue electrical conductivity), cell membrane properties (motor unit action potential aspect), motor unit properties (MU) (MU synchronism), and muscle architecture (fascicle angle and length, and muscle thickness) [16]. The latter undergoes changes during dynamic contractions, interfering with strength and power throughout the movement, and the length of muscle fibers, which may hinder or interfere with electromyographic signal interpretations [17].

Recently, some studies with divergent results on the effects of KT application on muscle activation, identified through the electromyographic signal, have been published. In four studies comparing muscle activation via EMG analysis, KT was used to treat some condition (e.g. rotator cuff injury,

patellofemoral syndrome, etc.) and two of them did not use a control group (without using the tape) [18-21]. Only Reynard et al. [21] were able to identify reduced muscle activation in one of the four muscles tested using KT, suggesting clinical relevance in the finding, since the upper trapezius usually shows increased activity in shoulder disorders.

In two studies involving healthy volunteers, Dos Santos Glória et al. [22] found no difference in rectus femoral muscle activation in soccer players. On the other hand, Watanabe [23] identified significantly lower activation of the Vastus Lateralis at the end of the eccentric phase and distal portion of the Rectus Femoris in the isometric knee extension phase for the group that used the most flexible EB.

Kase et al. [1] suggest that applying KT may increase muscle spindle reflex contraction and facilitate muscle contraction, and that one of the common goals in applying KT is to improve muscle performance. However, the evidence on these facts is sparse, controversial and of poor quality, especially in healthy people and athletes. In this context, this study aimed to verify the acute effect of EB on the performance of maximal voluntary isometric force and on muscle activation (EMG_{rms}) of the mid deltoid muscle at 90° of shoulder joint abduction in healthy subjects.

Methods

Ethical aspects

The study was approved by the Research Ethics Committee of Centro Universitário Presidente Antônio Carlos (Report 2014329). The research volunteers participated only after reading and signing the Informed Consent Form (ICF). PAR-Q (Physical Activity Readiness Questionnaire) was applied to identify healthy volunteers and exclude those who have any condition that makes it impossible to participate in the study [24].

Sample

The sample calculation was made through the equation proposed by Whitley et al. [25], in which a 95% confidence interval, an 80% level of sampling power and a significance level of 5% were adopted. Data were estimated from a similar study [26] that

used 20 healthy volunteers (23 ± 0.9 years). Thus, it was estimated the need for 25 volunteers to compose the sample of the current study.

One of the volunteers gave up and twenty-four healthy men (24 ± 4 years; 73.2 ± 13.9 kg; 1.80 ± 0.1 m), who did not know the EB technique and without any type of pain or history of injury on the right shoulder joint, expressed, by signing the ICF, interest in participating in the study. Exclusion criteria were: hypertensive individuals, with musculoskeletal diseases and metal nails in the right shoulder joint, with dermatological diseases or hypersensitivity to the application of EB or with neurological deficit. These criteria were adopted since the factors mentioned above generate variations in the application patterns of the EB technique, isometric exercise and electromyography.

Procedures

The volunteers visited the Laboratório de Biomecânica e Fisiologia do Exercício (LABIOFEX) four times. In the first, after signing the ICF and answering PAR-Q, anthropometric measurements were carried out, as well as skin sensitivity test for EB application and the random distribution in three groups: control groups (CG), Activated Elastic Bandage (AEB), and Non-activated Elastic Bandage (NEB). In addition, the volunteers became acquainted with the maximal isometric voluntary contraction (MVIC) test after having the purpose of the test and the equipment's operation explained to them, and were asked to perform two to three pilot tests to understand the effort and to identify the necessary position for its accomplishment.

The second and third visits were aimed at the reliability of MVIC and EMG_{rms} measurements, with a 48-hour interval between them. At the end of the third visit, the tape (AEB or NEB) was placed and the individual was instructed to remain with it until the next visit, with a minimum interval of 48h. Finally, the fourth visit was for interventions (AEB, NEB, and CG).

Elastic bandage

Initially, the skin was prepared with trichotomy and cleaned to remove grease and dead skin. As the goal was to facilitate muscle activation, the tape application began at the point of the muscle origin

and ended at its insertion point, aiming to stimulate muscle function due to the elastic properties of the tape, since it is believed that elastic fibers stimulate the muscle in the direction of its contraction, thereby improving movement. For the AEB group, the tape (KinesioSport®) was placed so as to avoid bending or rounding the edges of the bandage, with tensionless anchor close to the insertion of the muscle with the bands active at 100% and the inverted Y technique to have free access to position the electromyographic electrode in the muscle belly. The following procedure was performed: neutral shoulder position; base: lateral region of the clavicle; (active strip on shoulder extension associated with external rotation towards the deltoid humerus tuberosity); and anchor: neutral position in the deltoid humerus tuberosity. In the NEB group, the same procedures were adopted, but the tape was not tensioned, remaining without traction throughout the range of motion. The CG did not use any type of bandage. Figure 1 shows the tape application.

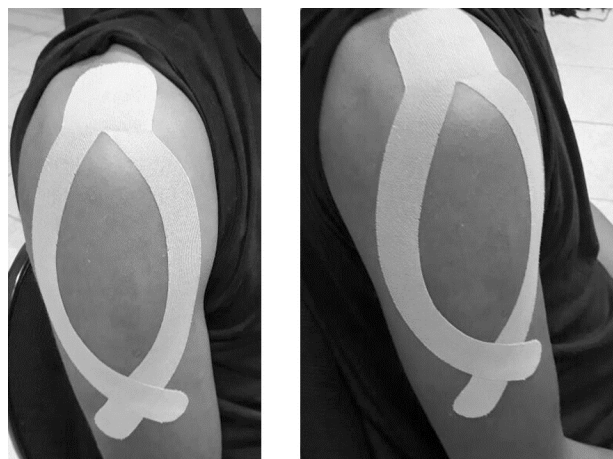


Figure 1 – Placement of elastic bandage over the middle deltoid muscle.

A physiotherapist specialized in the KinesioTaping technique performed the intervention during the research, determining the correct positioning of the bandage and its tension in each individual and providing information about its functioning, possible complications and the steps to be taken in case they appear. Only this professional was aware of whether the tape was tensioned (AEB) or not (NEB). None of the other researchers or research volunteers had this information, characterizing the study as double-blind.

Maximal Voluntary Isometric Contraction Test

The volunteers performed three MVICs of the dominant upper limb at 90° of shoulder joint abduction for 5 seconds, with an interval of 1 min between attempts. They remained in a sitting position with their backs resting on the back of the chair, feet flat on the floor and an inelastic brace wrapped around the abdomen and with the left shoulder resting on the wall to maintain the position and not to flex the left lateral trunk during MVIC. During the collections, two researchers were aware of the volunteer's positioning so that no execution error occurred. The first and last seconds in each contraction were disregarded for data analysis.

An adjustable handgrip tape was fixed to the ground and attached to a load cell (EMG System from Brazil, EMG 830C) with 2000 Hz sampling frequency per channel. The procedure is illustrated in Figure 2.

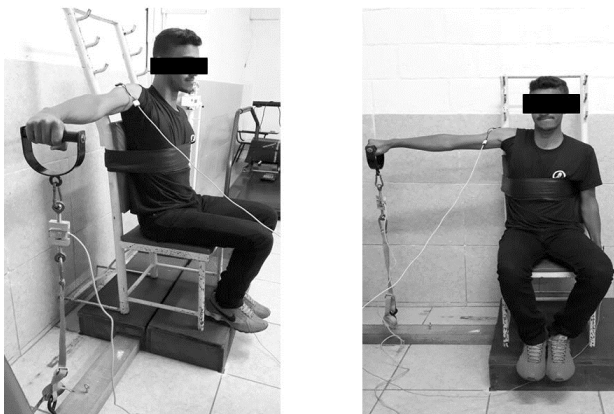


Figure 2 – MVIC test with shoulder joint abduction at 90°.

Electromyographic Signal Acquisition (EMG)

The electromyographic signal was recorded on the right upper limb middle deltoid muscle during the 5 s of MVIC at all visits. Previously, hair was removed, and the EMG electrode placement site cleaned with alcohol and slightly rubbed with sandpaper to remove dead skin tissue and reduce the impedance at the site. Electrode placement was oriented through the anatomical points described by Surface Electromyography (SENIAM) and electromyographic recording was conducted using a 16-channel acquisition system with 16-bit analog/digital converter (EMG System from Brazil, EMG 830 C) with 2000 Hz sampling frequency per channel. The first and last seconds in each acquisition were discarded for data analysis.

The reference electrode was fixed to the styloid process of the radius on the contralateral limb to the EMG signal collections. The electrode pairs were fixed with a distance around 20 mm between their centers. All preparation protocol of EMG signal acquisition was based on the Hermens et al protocol. [17] For data analysis, the EMG signal was filtered with a Butterworth-type 20Hz to 500Hz band pass filter, and the root mean square (RMS) value was calculated using a 50ms sliding window. To allow comparison of EMG signal between different individuals, data were normalized to a reference MVIC [27].

Statistical analysis

To verify the normality of the data, we used the Shapiro-Wilk test. Descriptive statistics were presented as mean and standard deviation of measurements. The measurements reliability was determined using the intraclass correlation coefficient (ICC parallel method), using the values obtained during both visits dedicated to reliability. The results interpretation followed the suggestion of Koo and Li [28], where values below 0.50 indicate poor reliability, values between 0.50 to 0.75 indicate moderate reliability, and values from 0.75 to 0.90 indicate good reliability. In addition, the typical error of measurement (TEM) was calculated [29] using the formula: $TEM = S \div \sqrt{2}$, in which S is the standard deviation of the sum of the differences between the pair of measurements and the degree of agreement between the measurements, determined through the representation of Bland and Altman [30]. The comparison between muscle force and activation during MVIC was made by one-way ANOVA, group factor. All analyzes were performed using SPSS 17.0 for Windows® software (IBM Corporation, New York, USA) and a statistical significance of $\alpha = 0,05$.

Results

Reliability of MVIC and EMG_{rms} measurements was made through the ICC, TEM, and the Bland and Altman test. These values were, respectively: MVIC (ICC = 0.92; TEM 2.5kgf; BIAS 1.7; IC -5.1 to 8.5) and EMG_{rms} (ICC = 0.49; TEM 182.8 μ v. BIAS 88.28; IC -418.4 to 595.0).

One-way ANOVA was not able to identify significant difference for strength ($p = 0.968$; $F = 0.032$) and muscle activation ($p = 0.593$; $F = 0.535$) between the tested groups (Figures 3A and 3B).

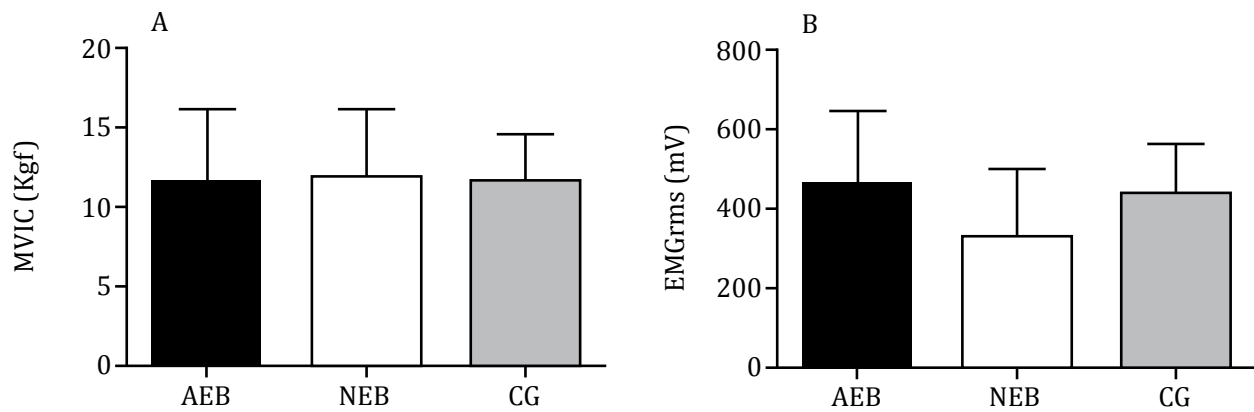


Figure 3 – A: mean of maximal voluntary isometric force levels of shoulder abduction at 90°; and B: mean of middle deltoid maximal activation during maximal voluntary isometric contraction.

Discussion

In this study, we investigated the acute effect of elastic bandage on the MVIF and EMG_{rms} of the middle deltoid muscle with the abducted upper limb 90° of the shoulder joint. We compared three different interventions, with 100% activated elastic bandage (AEB), without activation (NEB) and without any type of bandage (CG).

Regarding MVIF, corroborating the findings of several studies, no significant differences were found in MVIF in any of the comparisons made. Serra et al. [9] have identified no significant difference in any of the variables associated with strength during quadriceps MVIC after 24 h of KT or micropore placement. Similarly, Dos Santos Glória et al. [22] also found no significant difference in peak torque and performance of different types of jumps after KT or placebo tape application. In this study, the authors performed the tests immediately after tape placement, 30 min after and 24 hours after intervention. It is noteworthy that, in the current study, the tests were performed at least 48 hours after the tape application and, even so, no changes in MVIF were verified.

Using a model similar to the present study, Poomet al. [7], in order to eliminate the placebo effect, used active, non-activated EB and CG, and recruited healthy young people who were unaware of the intervention. The authors concluded that EB did not promote higher peak torque, higher total work output, or reduced peak torque time in healthy young adults and suggested that positive results found with KT so far can be attributed to placebo effects. In addition, Keenan et al. [5] tested the internal and external shoulder rotation strength

of healthy young volunteers and found no significant difference in the comparison between EB and placebo tape. They also suggested that, since tape is usually applied immediately before sports or competition, KT should not be used if the intention is to immediately improve these characteristics. Finally, two systematic reviews [31, 32] discourage the use of KT to improve strength or sports performance.

Regarding the electromyographic signal, it is typically suggested that KT is able to increase muscle activation by modulating its excitability through cutaneous and muscular mechanoreceptors. However, Yoosefinejad et al. [33] measured the amplitude of the reflex H (H max) and the wave M (M max) by the relationship between Hmax/Mmax of the lateral gastrocnemius and found no evidence to justify the postulated mechanism that KT has excitatory and inhibitory effects or influences the motor neuron, affecting the mechanoreceptors.

In the present study, no significant difference was identified in the EMG_{rms} signal of the middle deltoid of healthy men during the MVIC at 90° of shoulder joint abduction. This fact corroborates other findings in the literature, such as Cai et al. [34], who were unable to verify significant changes in the neuromuscular activity of the wrist extensor muscles and maximum grip strength immediately after the application of different use conditions of KT (facilitative and inhibitory). Such behavior seems to be independent of the size or type of muscle grouping, since Serrão et al. [35] also found no increase in myoelectric activity of the *vastus lateralis* and *vastus medialis* muscles when performing half-squat exercise after KT application in trained individuals. Similar results were reported

by Dos Santos Glória [22], who tested the isometric and dynamic strength of professional soccer players and found no change in *rectus femoris* muscle activation after KT application. However, Watanabe [23] identified a significant reduction in activation of the *vastus lateralis* and in the distal part of *rectus femoris* in the isometric and eccentric phase of knee extension with submaximal load after the application of highly elastic EB compared to the use of normal tape or control condition. The author also reported no difference in muscle activation related to different percentages of tape elongation (0%, 50% and 75%) and suggests that the effects observed are probably due to the elastic traction force promoted by the tape, which implies lesser muscle activation to accomplish the same task.

It should be noted that, in this study, the maximum isometric force of the middle deltoid with 100% activated EB was used. According to Yeung et al. [10], KT application from muscle origin to muscle insertion may potentiate reflex muscle contraction and facilitate muscle contraction. They suggest that the main effect of KT is to facilitate muscle spindle reflex through the retraction effect by means of dynamic actions, activating the mechanoreceptors necessary to facilitate muscle contraction and that this may not be achieved in isometric exercise. However, as already discussed, there is evidence that points to the absence of alteration in muscle activation during dynamic exercises [22, 35] and in different percentages of tape stretching [23] and which support the findings of this study.

The findings of the current study do not support the use of elastic bandage to increase strength production or modify deltoid muscle activation in healthy individuals. Such information has clinical applicability because it discourages those who intend to use this technique for these purposes.

There are some limitations in our findings. The low reliability of the EMG_{rms} measurement may have interfered with the actual values presented. However, all precautions and standards to ensure the quality of the electromyographic signal were taken. The double-blind method used in this study is a noteworthy fact, since it significantly increases its predictive power. In addition, the sample used was composed of healthy individuals and, generally, the elastic bandage technique is prescribed for therapeutic purposes. In this case, we suggest that future studies investigate the same variables in populations affected by musculoskeletal injuries or pain.

Conclusion

The results of the current study do not support the claim that elastic bandage, whether activated or not, facilitates muscle strength and/or activation in physically healthy people.

Therefore, we discourage the use of elastic bandage technique for healthy individuals for altering the force production or middle deltoid muscle activation.

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