Universidade de Aveiro Escola Superior de Saúde

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Efeito do sentido de aplicação da banda neuromuscular no tempo de reação do longo peroneal e na oscilação postural

Effect of the neuromuscular tape way of laying on fibularis longus latency time and postural sway

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Fisioterapia, realizada sob a orientação científica do Doutor Fernando Ribeiro, Professor Adjunto da Escola Superior de Saúde da Universidade de Aveiro e co orientação do Professor Mário Lopes, assistente convidado da Escola Superior de Saúde da Universidade de Aveiro.

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Palavras-chave

Tempo de latência, Bandas Neuromusculares, Estabilidade Postural

Resumo

Introdução: O entorse da Tibiotársica é uma lesão comum e o músculo Longo Peroneal tem um papel importante na estabilidade funcional da articulação. As Bandas Neuromusculares parecem melhorar a força muscular, embora pouco se sabe sobre o seu efeito no tempo de latência e na estabilidade postural.

Objetivos: Verificar o efeito das Bandas Neuromusculares no Tempo de Latência do Longo Peroneal e na estabilidade postural em indivíduos saudáveis.

Métodos: Trinta indivíduos foram randomizados para o grupo experimental 1 (n=10, idade 22.4 ± 3.0 anos), grupo experimental 2 (n=10, idade 22.6 ± 2.37 anos) e no grupo de controlo (n=10, idade 23.5 ± 6.3 anos). No grupo experimental 1, as bandas neuromusculares foram aplicadas desde a origem até à inserção do longo peroneal. No grupo experimental 2, as bandas neuromusculares foram aplicadas da inserção para a origem do longo peroneal. Após a aplicação da banda os elementos dos dois grupos experimentais permaneceram em repouso durante vinte minutos. No grupo de controlo não foi aplicada qualquer banda neuromuscular, tendo os invidíduos permanecido em em repouso ao longo de 20 minutos. Antes e após os 20 minutos de intervenção/controlo, a estabilidade postural foi avaliada numa plataforma de forças e o tempo de latência do longo peroneal foi avaliado com eletromiografia de superfície no decurso de uma perturbação forçada por inversão da tiobiotársica.

Resultados: Não foram encontradas diferenças entre grupos tendo em conta a idade, variáveis antropométricas, estabilidade postural, tempo de latência do longo peroneal, percentagem do pico de contração e tempo do pico de contração. Não foram encontradas diferenças dentro de cada grupo entre os valores antes e após-intervenção na estabilidade postural (CoPx, p= .485; CoPy, p=.995; CoP Total, p= .983; velocidade do CoP, p=.979; área do CoP, p=.506) e na eletromiografia (tempo de latência do longo peroneal, p= .548; percentagem do pico, p=.185; tempo do pico, p=.748).

Conclusão: As bandas neuromusculares não melhoram o tempo de latência do longo peroneal e a estabilidade postural em jovem adultos saudáveis.

Keywords

Latency time, Neuromuscular Taping, Postural Sway

Abstract

Introduction: Ankle sprains are a common injury and fibularis longus plays an important role improving functional stability. Neuromuscular tape seems to improve muscle force, although little is known regarding its effect on latency time and postural sway.

Objectives: To examine the effects of Neuromuscular Taping on fibularis longus latency time and postural sway in healthy subjects.

Methods: Thirty subjects were randomized into the experimental group 1 (n=10, age 22.4 ± 3.0 years), experimental group 2 (n=10, age 22.6 ± 2.37 years) and control groups (n=10, age 23.5 ± 6.3 years). Before and after the intervention, postural sway was assessed on a force plate and fibularis longus latency time was recorded with surface electromyography during a sudden inversion perturbation. In the experimental group 1, the Neuromuscular Tape was applied from the origin to the insertion of the fibularis longus and then subjects rested with the tape applied during 20 minutes. In the experimental group 2, the Neuromuscular Tape was applied from the insertion to the origin of the fibularis longus and then subjects rested with the tape applied during 20 minutes. The control group rested during the same period without Neuromuscular Tape.

Results: At baseline, no differences were found between groups regarding age, anthropometrics variables, postural sway, fibularis longus latency time, peak (%) and peak time. No significant differences were observed within each group between baseline and postintervention measures of Postural Sway (CoPx, p= .485; CoPy, p=.995; Total CoP, p= .983; CoP velocity, p=.979; CoP area, p=.506) and EMG (FLTL, p= .548; peak percentage, p=.185; peak time, p=.748).

Conclusion: Neuromuscular tape did not enhance peroneal reaction time and postural sway in young healthy subjects.

ABBREVIATIONS

FAI - Functional Ankle Instability

NMT - Neuromuscular Tape

KT - Kinesio Tape

MI - Mechanical Instability

EMG - Electromyography

BMI - Body Mass Index

MVIC - Maximal Voluntary Isometric Contractions

CoP - Center of Pressure

GRF - Ground Reaction Force

E1 - Experimental group 1

E2 - Experimental group 2

FLLT - Fibularis Longus Latency Time

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BACKGROUND

The ankle joint consists of three articulations: talocrural, subtalar and distal tibiofibular joints. These joints work in three planes: the sagittal plane (plantar/dorsal flexion), transverse plane (internal and external rotation) and the frontal plane (inversion and eversion) (Tanaka & Mason, 2011). The ankle motion results from the coordinated movements of these articulations. The lateral malleolus is longer and posterior to the medial malleolus; the plane is oblique to the plane of the floor and also to the transverse plane. This also increases the complexity of the biomechanics of the ankle. Three factors contribute to joint stability: osseous anatomy, static ligamentous and musculotendinous units (Tanaka & Mason, 2011). Joint capsule, ligaments, muscles and skin around the ankle are rich in various mechanoreceptors. These mechanoreceptors provide afferent impulses regarding joint movement, position, and sense of resistance. These mechanoreceptors are major contributors for proprioception and peroneal muscles reflexes (Ribeiro & Oliveira, 2011).

Acute lateral ankle injury is one of the most common injuries in the physically active people (Lardenoye et al., 2012). It is estimated that approximately 40% to 80% of these subjects may suffer repeated episodes of ankle sprain and develop chronic ankle instability (Hopkins, Brown, Christensen, & Palmieri-Smith, 2009;; Tanaka & Mason, 2011). Injuries to the lateral ankle ligament complex account for 16 to 21% of all musculoskeletal injuries (Hopkins et al., 2009; Lardenoye et al., 2012; Tanaka & Mason, 2011).

In the United States, ankle sprains have an estimated incidence rate of 2.15 per 1000 person per year and an estimated annual health care cost of $2 billion (Denyer, Hewitt, & Mitchell, 2013; Tanaka & Mason, 2011). The United Kingdom also has a high incidence rate, with as many as 302 000 patients each year attending emergency departments (Denyer et al., 2013; Tanaka & Mason, 2011).

The ankle sprain is the most common injury in 24 of 70 sports (Hiller et al., 2012). A ratio of 8 ankle sprains for each ankle fracture was observed in an hospital emergency department (Hiller et al., 2012). It is estimated that the number of visits to the hospital emergency service due to an ankle sprain range between 2.2 and 7 per year per 1000 subjects (Hiller et al., 2012).

In the Netherlands, ankle sprain affects an estimated 600.000 persons per year (Lardenoye et al., 2012). Fifty percent of these injuries happen in sports and in seventy-five percent the cause is an inversion trauma (Lardenoye et al., 2012). Recent research showed that, in the Netherlands, the mean total cost of a ankle sprain is about €360 giving an annual cost of approximately €100 million (Lardenoye et al., 2012).

An ankle sprain may result in stabilization deficits of the ankle and muscle strength/activation deficits. The peroneal muscles are evertors of the ankle, hence weakness of this muscular group may impair the ability to control inversion stresses, thus rendering the ankle vulnerable to inversion sprain and consequently to ankle instability (Delahunt, 2007). Indeed, a consequence of ankle injury is what several authors have called functional instability, due to impaired proprioception, peroneal muscle weakness, increased peroneal reaction time, impaired balance, decreased coordination, resulting in low level of effective control during sudden ankle inversion (Dias, Pezarat-Correia, Esteves, & Fernandes, 2011; Munn, Sullivan, & Schneiders, 2010).

It was reported in a systematic review realized by Van Rijn et al. (2008) that 15% to 64% of the people who suffered an ankle sprain had not recovered in 3 years. The principal residual problems included pain, chronic ankle instability and recurrent sprain. Daily life is appreciably impacted; for example, 15% of the people with ankle instability returned to work with some impairment, 6% were unable to maintain any occupational activity, while 72% of the people were unable to maintain their previous activity level (van Rijn et al., 2008). Ultimately, these subjects may develop ankle osteoarthritis, which can result in very poor quality of life. Among patients presenting for surgery for end-stage ankle osteoarthritis, 70% to 85% of the cases were posttraumatic (Hiller et al., 2012; van Rijn et al., 2008).

Ankle injuries particularly affect the active population. Re-injury rate can be as high as 80%, frequently leading to the development of chronic functional ankle instability (FAI) (Dias et al., 2011). Proprioception relates to the senses of position, movement and resistance. Proprioception can be considered a complex neuromuscular process that involves both afferent and efferent signals to maintain stability and orientation during activities (Ribeiro & Oliveira, 2007). Proprioceptive deficits and decreased joint position sense are common features of subjects with occurrence or re-occurrence of ankle ligament injury (Postle, Pak, & Smith, 2012). The ability to detect motion in the foot and make adjustments in posture in response to these detected motions is thought to be crucial for the prevention of injuries in the ankle joint. So, it appears that an ankle injury may lead to proprioceptive deficits and compromised neuromuscular control, thus reducing the ability to detect motion in the foot, and causing inadequate use of anticipatory/reactive muscular actions under dynamic conditions (Silva & Ribeiro, 2010).

Neuromuscular control can be defined as the interaction between the nervous and musculoskeletal systems to produce a desired effect, specifically in response to a stimulus (Jackson, Gutierrez, & Kaminski, 2009). During activity, dynamic and static restraints work together, via open-loop, reactive, and voluntary mechanisms, to maintain correct joint alignment in response to the forces imposed to the joint. In the ankle specifically, the lateral ligaments are highly innervated by mechanoreceptors, which together with the spindles in the peroneal muscles, that when rapidly or over stretched induce a reflex contraction to oppose the stretch (Jackson et al., 2009).

Several sensorimotor deficits have been proposed to contribute to FAI, including impaired proprioception, postural control, strength and neuromuscular firing. Neuromuscular firing considers the magnitude and the timing of the muscles that need to be activated, hence contributing to dynamic stability of the ankle (Hopkins et al., 2009). The short latency response is largely mediated by the muscle spindle. Alterations in muscle spindle sensitivity would affect the timing of the neuromuscular firing, as the primary spindle afferents would fire at varying thresholds (Ribeiro & Oliveira, 2008). Therefore, alterations in the muscle spindle could be a primary contributor to altered latency responses and ankle instability (Hopkins et al., 2009). When considering ankle instability, the peroneal muscles are of particular interest. While the peroneals serve as the primary evertors of the foot, perhaps more important is their role to maintain foot position during movement and functional activities. Inadequate firing of the peroneals could result in uncontrolled rear foot supination, which would be consistent with reports of ‘‘giving way’’ in patients with FAI (Hopkins et al., 2009).

Neuromuscular Tape (NMT) may be an important tool to prevent ankle injury. The development of NMT was born in Japan, in the seventy decade, by doctor Kenso Kase. He developed NMT based in Kinesiology and chiropraxy. Only twenty years later, this method appeared in Europe. According doctor Kenso, the muscles were not only used for the join movement but also influences body temperature, bloodstream and lymphatic circulation (Sijmonsa, 2004). NMT emerged in several colours, with 140% of elasticity, the same of the skin. NMT material is cotton with a standard proper for skin respiration. Also, NMT acquires a temperature similar to body temperature and can be used for a long time, without joint movements restriction (Halseth, Mcchesney, Debeliso, & Vaughn, 2004; Lins, Neto, Amorim, Macedo, & Brasileiro, 2013). NMT is commonly used to influence pain, muscular tonus, join function, postural correction, fascia relaxation, tendinous/ligamentary support, as well as to improve proprioception, bloodstream, lymphatic drainage and neuro reflex mechanisms.

The direction of application is very important in NMT (Chang, Chou, Lin, Lin, & Wang, 2010; Halseth et al., 2004; Huang, Hsieh, Lu, & Su, 2011a). According to Sijmonsa (2004), the fixed point is, most of the times, the origin of the muscle and, logically, the moving point of the muscle will be its insertion. When the NMT is applied from the origin to the insertion, the fascia is stimulated to slide towards the muscle shortening through the deep innervations of the subcutaneous tissue; stimulating muscle contraction. On the other hand, when the NMT is applied in the opposite direction (from the insertion to the origin), the fascia is stimulated to slide towards the muscle stretching and, consequently, receiving a relaxing stimulus. Nevertheless, Sijmonsa (2004) refers that there are not enough scientific evidence to support this hypothesis. In this regard, the available literature provides insufficient data to support this hypothesis. Even so, Sartre (2013), observed a relaxation effect on epicondylians muscles when NMT was applied from the insertion to the origin; thus supporting the hypothesis described above.

Being a type of injury with a high incidence and prevalence, the ankle sprain has been the subject of study for several researchers and clinicians, in order to investigate and develop potential therapeutic approaches and prevention strategies to reduce the risks of both primary lesions and recurrences. Hypothesizing that NMT could be a potential prevention strategy to mitigate the occurrence of ankle sprains, the purpose of the present study was to examine the effect of two NMT conditions compared to a no-tape condition on muscle activity of the fibularis longus during a sudden inversion perturbation and on postural sway in young healthy subjects.

LITERATURE REVIEW

This section summarizes briefly the current evident about the impact of NMT (in form of Kinesio Tape^{TM} or other brands) in proprioception, force, postural sway, electromyography variables and muscle function (Table 1).

The effects of NMT application (namely Kinesio Tape^{TM}) on proprioception are not consensual. One of the first studies performed to assess the effect of NMT application was conducted by Halseth et al. (2004)**.** The authors measured ankle joint position sense in thirty healthy subjects, before and after NMT application. Joint position sense consists in ability to recreate a randomly selected target position. The ankle measures were taken for both plantar flexion and inversion, at 20º of plantar flexion, using an active reproduction movement. The results of this study suggested that the application of NMT did not enhance ankle joint position sense**.** More recently, a study conducted in thirty boys with FAI, assessed the effect of adding NMT to an exercise program on muscle strength and proprioception of the ankle (Samah A. Elshemy, 2013). The subjects were divided into two groups: (A) NMT + rehabilitation exercise and (B) proprioceptive training + rehabilitation exercise. The rehabilitation exercise program included exercises to restore flexibility, range of motion and strength of the ankle muscle. Exercises were performed 30 minutes, six days per week for twelve successive weeks. The therapeutic application of the tape was sustained for five days, then removed 24 hours. Repetition of tape application and removal was conducted for 12 successive weeks. Ankle proprioception and ankle strength was evaluated after and before the 12 weeks. The results demonstrated that both NMT and proprioceptive training plus rehabilitation exercise induced a beneficial effect on dynamic position sense of the ankle and ankle strength, but the proprioceptive training group showed higher improvements (Samah A. Elshemy, 2013).

In studies assessing muscle force, the application of NMT did not induced any inhibition or facilitation in all tested muscles. One of the first studies was conducted in fourteen healthy college athletes and evaluated the peak torque and the total work of quadriceps and hamstring muscles (Fu et al., 2008). The results of the study did not support the existence of probable effects on muscle power induced by NMT (Fu et al., 2008). The results of a recent study performed by Gómez-Soriano et al. (2014) are similar. The objective of this study was to determine the effect of NMT applied over the gastrocnemius muscles on muscle tone, extensibility, EMG variables and muscle strength. NMT and sham-tape were applied in gastrocnemius muscles of 19 healthy subjects in two randomized sessions. Outcome measurements were taken at baseline at 10 min and 24 h after the intervention and included passive resistive torque to ankle dorsiflexion, dorsiflexion passive range of motion, gastrocnemius medialis surface EMG and maximal isometric voluntary force. No significant differences were found between the sham-tape and NMT groups for passive resistive torque, passive range of motion, and maximal plantar flexion isometric voluntary force. These results demonstrate that the application of NMT in the gastrocnemius muscles had no effect on healthy muscle tone, extensibility or strength.

Huang, Hsieh, Lu, & Su, (2011) studied the effects of NMT on muscle activity in thirty-one healthy inactive adults. The authors analysed this effect in a vertical jump, using a force platform and electromyography. NMT was applied from insertion to origin in triceps surae, using a Y shaped. The results indicated an increase only in muscle activity of the medial gastrocnemius. No benefits were observed in the vertical jump.

Regarding postural sway, the studies conducted so far seem to demonstrate a beneficial effect of NMT application compared with a placebo group, nonetheless when compared to balance training, the last one showed better results. Akbari, Sarmadi, & Zafardanesh (2014) divided thirty healthy female students into two equal groups: one group received ankle taping and the other balance exercise. The balance exercise group performed each session enduring 40 minutes, 3 sessions per week for 6 weeks. Ankle taping was applied for 6 weeks and was changed three times a week. Before and after the interventions, stability indices were measured in bilateral and unilateral stance positions with the eyes open and closed. The results of this study supported the positive effects of balance exercise on postural stability; and also partially supported the positive effects of taping. The results showed that balance exercise has effects on a greater number of balance indices comparing to taping. In another study, Naranjo & Rodríguez-Fernández (2014) concluded that the application of NMT immediately improved standing balance, expressed by better results of CoPy and total CoP. They analysed 16 healthy athletes, divided into two groups (NMT and placebo group) and evaluated center-of-pressure (CoP) variables in unipodal balance tests, with eyes closed and with eyes opened.

The effect of NMT in muscle latency time is not consensual. Briem et al. (2011) tested fifty-one male athletes with functional stability of both ankles for muscle activity of the fibularis longus, recorded with surface EMG, during a sudden inversion perturbation. Each participant was tested under 3 conditions: ankle taped with nonelastic white sports tape, ankle taped with NMT (the NMT was applied in a single strip, from origin to insertion of the fibularis longus muscle) and no ankle taping. Significantly greater mean muscle activity was found when ankles were taped with nonelastic tape compared to no tape, while NMT had no significant effect on mean or maximum muscle activity compared to the no-tape condition. In this sense, the efficacy of NMT in preventing ankle sprains via the same mechanism is unlikely, as it had no effect on muscle activation of the fibularis longus. In a similarly study, Trégouët, Merland, & Horodyski (2013) compared the effects of different ankle taping methods on lower leg EMG of twelve healthy participants. Each subject was tested in three conditions (non-elastic bandage, elastic adhesive bandage wrap and non-taped control). All tape conditions showed a reduced peroneal latency; on the other hand the muscle latency did not exhibit any differences between taping styles.

Regarding to the way of laying of NMT, a study (Martínez-Gramage, Ibáñez Segarra, López Ridaura, Merelló Peñalver, & Tolsá Gil (2011) analyzed the immediate effect of NMT with two techniques (inhibition and facilitation) on the reflex response of vastus medialis of thirty healthy subjects. The authors compared intensity and latency of the reflex response of the vastus medialis under three different conditions: without NMT, with NMT origin-insertion and with NMT insertion-origin. They calculated the response intensity (maximum peak of the normalized EMG) and latency (the time it takes between the start of the imbalance and the onset of reflex response) and found no differences between the three conditions. The results suggested that the application of KT origin-insertion and KT insertion-origin has no immediate effect on the reflex response of the analyzed muscle. Similarly, Sartre, Fabri, & Morana (2013) assessed the effects of a NMT strip on epicondylian muscle activity at rest, according to the way of laying (origin-insertion or insertion-origin) in 54 subjects, divided into two groups of 27 subjects. The surface electromyographic activity was recorded on the epicondylian muscles at rest, before and after laying the strip. In the insertion to origin group the EMG activity at rest was significantly lower (detoning effect) with the NMT than the activity without the strip. The strip in the origin to insertion group did not induce any significant effect.

It is important to note that recently two meta-analysis and one systematic review were conducted on this topic. The first meta-analysis was realized by Williams, Whatman, Hume, & Sheerin (2012) and included 10 articles. The authors concluded that NMT may have a small beneficial effect on strength, proprioception, and active range of motion and no substantial evidence exists to support the use of NMT in pain or muscle activity. The authors indicated that despite having some substantial effects on muscle activity, it is unclear whether these changes are beneficial or harmful. In this sense, they argued that little quality evidence exist to support the use of NMT over other types of elastic taping in the prevention of sports injuries. More recently Csapo & Alegre (2014) included 19 studies in a meta-analysis about the effect of NMT on muscle strength. In this study, the main conclusion is that the application of NMT does not promote strength gains in healthy adults. It is important to mention, that the overall methodological quality of studies investigating the potential of NMT to improve muscle strength is moderate to good and tends to be lower in studies reporting significant effects. The systematic review conducted by Espejo & Apolo (2011), included 37 studies examining the effect of NMT on pain, flexibility and joint mobility, in proprioception, strength, on the venous and lymphatic circulation, on the improvement of capacity, and neurological benefits. The results were not consensual, but authors concluded that the NMT could be a complementary technique that empirically provides benefits.

Table 1 - Summary of the articles included in the literature review

Authors	Year	Participants	Intervention	Variables	Results
Halset et al.	2004	30 healthy subjects (15 men and 15 women)	- Kinesio Tape - Untaped	Reproduction of joint position sense	No differences between groups
Samah et al.	2013	30 boys with Functional Instability	- Kinesio Tape - Proprioceptive training	- Active Repositioning sense - Peak Torque	Improvement in both groups. Proprioceptive training was more beneficial
Fu et al.	2008	14 healthy athlete (7 men and 7 women)	- Without taping, immediately after taping, 12h after taping and with the tape still in situ	- Concentric and eccentric muscle strength (quadriceps and hamstring)	No differences
Gómez-Soriano et al.	2014	19 healthy volunteers (8 males and 11 females)	- Kinesio Tape - Sham-tape	- Passive resistive torque (ankle dorsiflexion) - Gastrocnemius muscle extensibility - Maximal voluntary isometric force - Muscle EMG activity	No differences
Huang et al.	2011	31 healthy adults (19 males and 12 females)	- Kinesio Tape - Non-elastic Tape - Control group	- Vertical ground reaction force - EMG activity	Increase in the Vertical ground reaction force after Kinesio Tape
Akbari et al.	2014	30 female students	- Balance exercise - Kinesio Tape	- Stability indices	No significant differences; but balance exercise had effects on a greater number of balance indices comparing to tape

Naranjo & Rodríguez-Fernández	2014	16 healthy subjects	- Kinesio Tape - Placebo group	Center of pressure analysis in unipodal stance, with eyes closed and with eyes opened	The kinesio Tape group improved the standing balance
Briem et al.	2011	51 healthy male	- Kinesio Tape (origin-insertion of fibularis longus) - Non-elastic Tape - No tape	- Mean Muscle activation - Peak Muscle activation - Perception of stability	No differences
Trégouët et al.	2013	12 healthy subjects	- Non-elastic tape - Elastic adhesive bandage - Non-taped control	- Peroneal Latency Time	No differences
Martínez-Gramage	2011	30 healthy subjects	- Three Kinesio tape conditions (on vastus medialis): Origin-Insertion Insertion-Origin Without tape	- Latency Time - Peak force (% maximal voluntary isometric contraction)	No differences
Sartre et al.	2013	54 healthy subjects	- Two Kinesio Tape conditions (on epicondylians): Insertion-Origin Origin-Insertion	- Surface electromyographic activity at rest, before and after laying the strip	No effects in "origin-insertion" condition EMG activity at rest was significantly lower (detoning effect) in "insertion-origin" condition

Legend: EMG, electromyography

PURPOSE

The purpose of the present study was to examine the effect of two NMT conditions compared to a no-tape condition on muscle activity of the fibularis longus during a sudden inversion perturbation and on postural sway in young healthy subjects.

It is hypothesized that NMT could be a potential prevention strategy to mitigate the occurrence of ankle sprains by decreasing fibularis longus latency time during a sudden inversion perturbation and by increasing postural sway in young healthy subjects.

METHODS

Study design

This was a controlled laboratory study conducted in young adults. Thirty young healthy subjects were equally randomized into three groups, two experimental groups receiving NMT and a control group. The subjects reported to the laboratory once for assessment of muscle activity of the fibularis longus during a sudden inversion perturbation and postural sway before and after the application of NMT for 20 minutes or a 20-minute control period.

Participants

The sample consisted of 30 healthy volunteers, students at the University of Aveiro (15 female and 15 male). They were selected by convenience sampling. Subjects without regular sports practice (>2 times per week) and without low back/lower limb pain were recruited for this study. Subjects were excluded according to the following criteria: ankle injury in last year, ankle instability, lower limb surgery, lower limb fracture and neurologic injury in the lower limb. The study tests were performed in the dominant leg. Dominant limb was defined as the limb used to kick a ball. The 30 participants were divided into three groups, the control group and two experimental groups. In the first experimental group, NMT was applied from origin to insertion of the fibularis longus. In the second experimental group, NMT was applied from insertion to origin of the fibularis longus.

Prior to participating, the purpose of the study and the experimental protocol was explained to the subjects. All participants provided written informed consent and all procedures were conducted according the declaration of Helsinki. The subjects were familiarized with the experimental protocol and apparatus. Each subject completed all of the data collection in one session.

Procedures

All the assessments were conducted in the Laboratory of Human Movement and Rehabilitation at the University of Aveiro.

First, each subject read a document with the explication of the study and provided written informed consent. Then, subjects were randomly (block randomization, 1:1:1) divided into three groups with identical number of elements: the control group (n=10), the experimental group 1 (E1, n=10), in which the NMT was applied from the origin to the insertion of the fibularis longus (to promote muscle activation), and the experimental group 2 (E2, n=10), in which the, NMT was applied from the insertion to the origin of the fibularis longus (to induce a relaxation effect).

Socio-demographic and anthropometric data were first collected to characterise the sample. Height and weight measurements were attained using a standard wall-mounted stadiometer and scale, respectively. Body Mass Index (BMI) was calculated from the ratio of weight (kg) to squared height (m^2). The length from the head of the fibula to the lateral malleolus was measured. This measure was used to calculate the EMG electrodes placement.

Then, the hair of the leg was shaved and the skin cleaned with an alcohol solution to minimize impedance of surface electrodes. Afterwards, the EMG electrodes were placed in the muscles fibularis longus following SENIAM recommendations; i.e. the subject was in long sitting with the lower limb medially rotated and the electrodes were placed at 25% on the line between the tip of the head of the fibula to the tip of the lateral malleolus.

After that, in order to normalize the EMG signal, the participants performed two maximal voluntary isometric contractions (MVIC) lasting 6 seconds each of the fibularis longus (Barbado Murillo, Sabido Solana, Vera-Garcia, Gusi Fuertes, & Moreno, 2012). The MVICs were gathered with the participants in a supine position and the foot in a neutral position. An examiner manually resisted eversion contractions during each test (Barbado Murillo et al., 2012). The participants were verbally encouraged during the execution of the maximal contractions.

Then, the order of the assessments (postural sway / muscle activity during sudden inversion) was randomized for each participant.

Participants performed 3 sudden inversion perturbations for the ankle in test. The sudden inversion perturbations were randomly (automatic system controlled by a computer chip) applied to each ankle to limit pre-activation. Only the sudden inversion perturbations on the ankle in test were analysed. During each trial, the participant stood on 2 feet on the trapdoor and the examiner pressed a bottom to open the door, creating an inversion perturbation of 30° (Figure 1). The open mechanism was programmed to open randomly between 5 and 20 seconds after the bottom has been pressed. All the mechanism is independent of the examiner. Three trials, with a 30-second rest between each were collected. During all the tests, EMG data was continuously recorded.

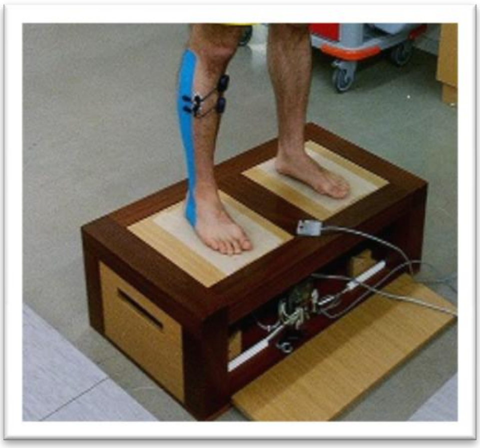

Figure 1– Participants' position on the trapdoor to assess EMG variables in an inversion perturbation

Postural sway was assessed in a force platform (AMTI BP400600-2000, AMTI). Participants were asked to perform three valid single-leg stance trials of 20 seconds with the eyes open (Figure 2). Participants had to stand as still as possible, with knee at full extension, keeping their hands on their hips. A trial was considered invalid if a participant displaced his/her standing leg, touched the floor with the contra-lateral leg or if a hand was used to regain balance. Postural sway data were sampled at 1000 Hz by a 600 mm x 400 mm force plate (AMTI BP400600-2000, AMTI). Giganet Vicon with Software Vicon Nexus 1.8.5 collected force and moment in three axis (X, Y and Z). A custom MATLAB R2014a (MathWorks, Madrid, Spain) program was used for data reduction. The variables derived from the analysis were Center of Pressure (CoP) displacement [(antero-posterior (CoPx) and medio-lateral (CoPy)], CoP speed, 95% of ellipse area and total CoP displacement.

Both postural sway and sudden inversion perturbations were performed with bare feet and participants were allowed to perform three practice trails before testing.

Postural sway and EMG activity during sudden inversion perturbations were evaluated at baseline and after the interventions/control period in the 3 groups.

Figure 2 - Postural Sway assessment on a force platform

Interventions: neuromuscular taping / control period

The blue NMT (CureTape, Fysiotape; Enschede, Netherlands) was applied in two experimental groups. In E1 the NMT was applied from the origin to the insertion of the fibularis longus. In E2 the NMT was applied from the insertion to the origin of the fibularis longus.

For NMT application, the participants laid supine with the ankle flexed and inverted. In E1 the NMT was applied from fibular head, passing behind the lateral malleolus and ending on the plantar surface of the base of first metatarsal. In E2 the NMT was applied from the plantar surface of the base of the first metatarsal, passing behind the lateral malleolus and ending in the head of the fibula. NMT was applied without tension in the two groups. The participants of both groups rested in a sitting position with the NMT applied for 20 minutes before get tested again.

The control group did not receive any tape application. This group rested for the same period of the time (20 minutes) of the intervention in the experimental groups.

Electromyography analysis

EMG muscle activity of the fibularis longus muscle was recorded with surface electrodes and sampled at 1000 Hz (D. Rosenbaum, H.-P. Becker, H. Gerngrob, 2000; Denyer et al., 2013; Vaes, Duquet, & Van Gheluwe, 2002) using a wireless EMG system (EMG Myon 320, Schwarzenberg, Switzerland), with a signal bandwidth of 25 to 500 Hz (Hopkins et al., 2009; Papadopoulos, Nikolopoulos, & Athanasopoulos, 2008). Simultaneously, signals were collected by another electrode placed close to the trapdoor to determine the timing of the perturbation. Data were collected for a maximum of 25 seconds for each trial, and 5 seconds were used for data analysis.

Data were analysed with AcqKnowledge, version 3.9.0 (Biopac System, Goleta, USA). Variables of interest included the mean and peak magnitude of the EMG signal and the time from perturbation to peak EMG. The raw EMG data were high-pass filtered at 50 Hz, full wave rectified, and the root-mean-square of the signal was derived using a moving window of 100 milliseconds (Dias et al., 2011). Then, the baseline EMG amplitude was estimated during a time window of 250 ms before the opening of the trapdoor. The threshold criteria to calculate the latency time was 3 standard deviation above de mean baseline (Dias et al., 2011). All data were normalized to the maximum signal collected during the MVIC.

Statistical Analysis

Statistical analysis was performed using IBM SPSS statistics 21.0 (IBM Corporation, Chicago, IL). The normality of data distribution was tested with the Shapiro-Wilk test. The data were normally distributed. Descriptive statistics were used to calculate the mean and standard deviation. An analysis of variance (ANOVA) was used to evaluate differences at baseline between the three groups. To examine the effect of the interventions on postural sway and EMG data, a 3 × 2 (E1/E2/Control × baseline/ post) mixed-model ANOVA was used to compare results between groups over time (group × time). $P<0.05$ was considered indicative of statistical significance.

RESULTS

Sample characterisation

Fifteen male and 15 female healthy adults (n=30; mean age 22.24 ± 2.66 years old) divided into 3 groups composed the sample of this study (Table 1). No significant differences for age, height, weight and BMI were found between groups.

Table 2 - Participants´ characterisation

Characteristics	E1 (n=10)	E2 (n=10)	Control (n=10)	p-value
Age (years)	22.4 ± 3.03	22.6 ± 2.37	21.7 ± 2.74	.120
Height (cm)	169.7 ± 4.69	171.5 ± 10.45	169.1 ± 9.86	.425
Weight (Kg)	66.6 ± 8.83	70.9 ± 17.41	71.5 ± 15.83	.259
BMI (Kg/cm^2)	22.7 ± 3.42	23.7 ± 3.44	24.8 ± 3.60	.276

BMI, body mass index.

Baseline Values

The values of postural sway and muscle activity at baseline are presented in table 2. No significant differences were found at baseline between groups in any variable. Nonetheless, the values of peak percentage were higher in E2 group and lower in the control group, with a p-value almost reaching significance.

Table 3 - Postural Sway and muscle activation at baseline

Characteristics	E1 (n=10)	E2 (n=10)	Control (n=10)	p-value
CoPx (cm)	3.82 ± 0.74	3.44 ± 1.00	4.21 ± 0.86	.518
CoPy (cm)	2.96 ± 0.58	2.92 ± 0.27	3.12 ± 0.35	.684
Total CoP (cm)	94.57 ± 25.05	89.21 ± 19.71	83.18 ± 13.60	.166
CoP speed (cm/s)	4.50 ± 1.19	3.98 ± 0.44	3.96 ± 0.65	.169
CoP Area (cm^2)	8.89 ± 3.95	7.76 ± 3.52	10.09 ± 3.16	.091
FLLT (ms)	93.74 ± 14.98	81.24 ± 14.21	87.12 ± 8.20	.568
Peak (%)	125.15 ± 27.86	152.06 ± 61.46	95.30 ± 44.09	.058
Peak Time (ms)	110.10 ± 48.5	118.17 ± 47.78	123.68 ± 28.95	.198

CoPx, antero-posterior displacement of the center of pressure; CoPy, medio-lateral displacement of the center of pressure; Total CoP, total distance of the center of pressure; CoP speed, velocity of the center of pressure; FLLT, Fibularis Longus Latency Time; Peak (%), percentage of the maximal isometric muscular contraction; Peak time, time between muscular activation and maximum peak.

Baseline – postintervention comparisons

Regarding postural sway (Table 3), no interaction group X time was observed for CoPx (p= .485), CoPy (p= .995), total CoP displacement (p= .983), CoP speed (p= .979), and CoP area (p= .506). No significant differences were observed within each group between baseline and postintervention measures of CoPx, CoPy, Total CoP oscillation, CoP speed, and CoP area.

Table 4 – Impact of the intervention on postural sway

	E1 (n=10)	E2 (n=10)	Control (n=10)
CoPx (cm)			
Baseline	3.82 ± 0.74	3.44 ± 1.00	4.21 ± 0.86
Post	3.82 ± 0.61	3.9 ± 1.01	4.22 ± 0.89
CoPy (cm)			
Baseline	2.96 ± 0.58	2.92 ± 0.27	3.12 ± 0.35
Post	3.00 ± 0.52	3.05 ± 0.32	3.05 ± 0.31
Total CoP (cm)			
Baseline	94.57 ± 25.05	89.21 ± 19.71	83.18 ± 13.60
Post	90.05 ± 19.27	83.18 ± 16.25	79.51 ± 15.24
CoP speed (cm/s)			
Baseline	4.5 ± 1.19	3.98 ± 0.44	3.96 ± 0.65
Post	4.29 ± 0.92	3.96 ± 0.77	3.79 ± 0.73
CoP Area (cm^2)			
Baseline	8.89 ± 3.95	7.76 ± 3.52	10.09 ± 3.16
Post	8.83 ± 2.55	9.05 ± 3.50	9.60 ± 3.05

CoPx, antero-posterior displacement of the center of pressure; CoPy, medio-lateral displacement of the center of pressure; Total CoP, total distance of the center of pressure; CoP speed, velocity of the center of pressure; FLTL, Fibularis Longus Time Latency; Peak (%), percentage of the maximal isometric muscular contraction; Peak time, time between muscular activation and maximum peak.

No interaction group X time was observed in fibularis longus latency time (p= .548), peak percentage (p= .185) and peak time (p= .748) (Table 4). Also no significant differences were observed within each group between baseline and postintervention in all the EMG variables.

Table 5 - Impact of the intervention on EMG variables

	E1 (n=10)	E2 (n=10)	Control (n=10)
FLLT (ms)			
Baseline	93.74 ± 14.98	81.24 ± 14.21	87.12 ± 8.20
Post	89.89 ± 15.58	81.57 ± 16.64	84.97 ± 9.24
Peak (%)			
Baseline	125.15 ± 27.86	152.06 ± 61.46	95.30 ± 44.09
Post	139.31 ± 91.07	230.13 ± 171.95	99.11 ± 49.45
Peak Time (ms)			
Baseline	110.1 ± 48.5	118.17 ± 47.78	123.68 ± 28.95
Post	94.85 ± 38.02	110.15 ± 49.23	118.60 ± 21.97

FLLT, Fibularis Longus Latency Time; Peak (%), percentage of muscular contraction, Peak time, time between muscular activation and maximum peak;

DISCUSSION

The main purpose of the present study was to assess the impact of two different applications (changing the way of laying) of NMT on postural sway and fibularis longus latency time. Our results do not confirm the hypothesis that the NMT could be a potential prevention strategy to mitigate the occurrence of ankle sprains, since our results indicate that the application of NMT for 20 minutes has no effect on postural sway and fibularis longus latency time.

The baseline values of fibularis longus latency time obtained in the present study are within the reference values found in the literature (Ebig et al., 1997; Forestier & Terrier, 2011; Hopkins et al., 2009). Similarly, the values of postural sway, namely CoPx, CoPy and CoP speed found in our study are similar to those reported previously (Naranjo & Rodríguez-Fernández, 2013).

It was reported that in general this kind of tape: increases neuromuscular recruitment; provides extra tactile stimulus, hence activating cutaneous receptors; facilitates motor unit activation; increases interstitial space, thus enhancing blood flow; and enhances muscle activation (Kase k, Wallis, 2003; Sijmonsa, 2004). However, in the present study, no significant alterations were detected in the EMG activity of the fibularis longus, indicating that tactile stimulation promoted by the NMT was not sufficient to change the recruitment of this muscle in this particular action.

The results of the present study are in line with previous studies (Fu et al., 2008; Vithoulka et al., 2010) showing that NMT applied directly to the femoral quadriceps of healthy subjects has no immediate effect on quadriceps peak torque. In the study by Briem et al. (2011) that assessed the effect of NMT on the level of activation of the fibularis longus muscle during a “sudden disturbance” of the ankle in 51 healthy athletes and found no significant alterations in muscle activation. Similarly, Martínez-Gramage et al. (2011) analyzed the immediate effect of NMT with two techniques (inhibition and facilitation) on reflex response of vastus medialis and reported that the application of NMT from the origin to insertion and from insertion to origin does not have an immediate effect on the reflex response of the analyzed muscle. Likewise, a recent study by Sartre et al. (2013) assessed the effect of a NMT, according to the way of laying (inhibition and facilitation) in epicondylians muscles; the authors only observed effects in the inhibitory application (compared with the placebo group).

Our sample was composed by healthy subjects, which leads us to believe that NMT applied to this population has no effect whatsoever, since they exhibited no neuromuscular dysfunctions or muscle weakness that could be minimized by applying this technique. Additionally, it is questionable whether applying a bandage to the skin surface can alter the recruitment of motor units, thereby enhancing neuromuscular performance. Finally, the hypothesis that NMT would produce an increase in the interstitial space, enhancing blood flow and possibly favouring a rise in muscle activation, was not proven in the present study, suggesting that the tension produced by the bandage is not sufficient to promote these alterations.

Limitations and future research

Several limitations need to be acknowledged. First, a small convenience sample composed by healthy subjects was included in this study, which limits the generalisation of our results. Second, the second evaluation was only twenty minutes after the intervention. It could be important to evaluate at different time periods and for a long time, for instance at 1h, 3h, and 6h hours after intervention. Third, healthy subjects do not present muscle weakness or impaired postural sway, so the room for improvement with NMT is small. It is recommended that future studies use subjects with FAI. This would be very important considering that a recent study demonstrated improvements in result of NMT application on dynamic position sense of the ankle and ankle muscles strength in children with FAI (Samah A. Elshemy, 2013).

CONCLUSION

The results of the present study show that NMT application, independent of the way of laying, has no effect on muscle activity of the fibularis longus during a sudden inversion perturbation and on postural sway in young healthy subjects. The present results jeopardise the use of NMT as a prevention strategy to mitigate the occurrence of ankle sprains in healthy individuals with no FAI. Future studies are important to add knowledge to the issue of NMT, in order to scientifically prove the information that is transmitted through the NMT manuals.

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ANNEXES

ANNEX I

"Declaração de Consentimento Informado"

Declaração de Consentimento Informado

Conforme a “Declaração de Helsínquia” da Associação Médica Mundial (Helsínquia 1964; Tóquio 1975; Veneza 1983; Hong Kong 1989; Somerset West 1996, Edimburgo 2000; Washington 2002, Tóquio 2004, Seul 2008, Fortaleza 2013)

<u>Tipo de estudo:</u> Dissertação do Mestrado em Fisioterapia da Escola Superior de Saúde da Universidade de Aveiro com a orientação do Professor Doutor Fernando Manuel Tavares da Silva Ribeiro e com a co orientação do Mestre Mário Alexandre Gonçalves Lopes.

<u>Título do estudo:</u> "O efeito do sentido de aplicação da banda neuromuscular no tempo de reação do longo peroneal e na oscilação postural"

Eu, abaixo-assinado, ____ (nome completo):

Fui informado de que o Estudo de Investigação acima mencionado se destina a avaliar o equilíbrio e o tempo de reação do longo peroneal, antes e após a aplicação da banda neuromuscular.

Sei que neste estudo está prevista a realização de dois testes, um de equilíbrio (plataforma de forças) e outro teste que medirá o tempo de reação do longo peroneal através de eletromiografia de superfície (Trapdoor), tendo-me sido explicado em que consistem e quais os seus possíveis efeitos. Também sei que neste estudo, os voluntários serão divididos em três grupos e que, cada grupo terá uma intervenção diferente.

Foi-me garantido que todos os dados relativos à identificação dos participantes neste estudo são confidenciais e que será mantido o anonimato e, com este requisito, autorizo a divulgação dos resultados obtidos no meio científico.

Fui informado que tenho o direito de recusar a qualquer momento a participação no estudo sem me expor a represálias e ver garantida a confidencialidade da informação prestada a fim de reduzir ao mínimo as consequências da investigação sobre a minha integridade física e mental e minha personalidade.

Compreendi a informação que me foi dada, tive oportunidade de fazer perguntas e as minhas dúvidas foram esclarecidas.

Aceito, assim, participar de livre vontade no estudo acima mencionado.

Assinatura: ______________________________ Data: _____________

O investigador: _________________________

ESTE DOCUMENTO É COMPOSTO DE 1 PÁGINA E FEITO EM DUPLICADO: UMA VIA PARA O INVESTIGADOR, OUTRA PARA A PESSOA QUE CONSENTE

ANNEX II

"Informação aos participantes"

Informação ao Participantes

O efeito do sentido de aplicação da banda neuromuscular no tempo de reação do longo peroneal e na oscilação postural

Está a ser realizado um estudo de investigação que pretende avaliar o tempo de reação do longo peroneal e a oscilação postural perante diferentes aplicações de bandas neuromusculares. Assim, vimos convidá-lo(a) a participar nesta pesquisa. Antes de decidir participar é importante que compreenda o porquê da investigação. Assim, pedimos que leia atentamente a informação e converse sobre a sua participação com outras pessoas, se assim o entender. Se existir algum aspeto que não esteja claro para si ou se precisar de mais informação, por favor recorra aos investigadores.

Qual é o propósito do estudo?

O presente estudo foi desenvolvido para avaliar o efeito do sentido de aplicação de bandas neuromusculares no tempo de reação dos peroneais e na oscilação postural, em indivíduos saudáveis.

Perguntas mais frequentes:

Porque é que fui escolhido?

Para este estudo, foi selecionada uma amostra por conveniência. Essa amostra é constituída pelos alunos da Universidade de Aveiro, desde que cumpram os critérios de seleção.

Tenho de participar?

A decisão de participar, ou não, é completamente sua. Se decidir participar vamos pedir-lhe que leia e assine um formulário de consentimento informado, mas é totalmente livre de desistir a qualquer momento, sem que para tal tenha de dar qualquer justificação. A decisão de desistir ou de não participar, não afetará a qualidade dos serviços de saúde que lhe são prestados agora ou no futuro, nem implicará qualquer consequência para si.

O que me acontecerá caso decida participar?

Se decidir participar, por favor diga-o a um dos investigadores. Seguidamente, o investigador pedir-lhe-á que leia e assine o formulário de consentimento informado, entregando-lhe uma cópia deste documento, e tendo em conta a sua disponibilidade, combinará uma data para a avaliação.

Nenhum destes testes provoca qualquer desconforto. No entanto, se decidir não participar neste estudo, em nada será afetado.

O que tenho de fazer?

Apenas lhe solicitamos que compareça no horário combinado para preenchimento da Declaração de Consentimento Informado e para a recolha de dados (tempo de latência do longo peroneal, deslocamento do centro de pressão médio-lateral, ântero-posterior e total, velocidade do centro de pressão e área no Postural Sway). Os horários disponíveis ser-lhe-ão comunicados pelo investigador.

Quais são os efeitos secundários de qualquer tratamento que eu vá receber quando participar?

Não existem efeitos secundários conhecidos.

Quais são as possíveis desvantagens e riscos se eu resolver participar?

Não existem quaisquer desvantagens de participar no estudo. No entanto, se tiver alguma preocupação, por favor contacte os investigadores para se esclarecer.

Quais são os possíveis benefícios se eu resolver participar?

Não existem benefícios diretos de participar no estudo. No entanto, a informação que se obterá através deste estudo poderá ajudar a desenvolver intervenções mais completas.

A minha participação será confidencial?

Toda a informação recolhida no decurso do estudo será mantida estritamente confidencial. Os dados recolhidos no computador não serão gravados com o seu nome, mas sim com um código, para que ninguém fora da equipa de investigação o/a possa identificar, e o computador será protegido com uma palavra-chave.

O que acontecerá aos resultados do estudo?

Os resultados do estudo serão analisados e incorporados numa Dissertação de Mestrado e publicados em Revista Científica. No entanto, em nenhum momento o participante será identificado. Se gostar de obter uma cópia de qualquer relatório ou publicação, por favor diga ao investigador como o contactar após o estudo.

Contactos para mais informações sobre o estudo

Se quiser obter mais informações sobre o estudo, pode telefonar ou escrever para:

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Muito obrigada, desde já, pela sua atenção.