



Effects of Kinesio taping on scapular kinematics of overhead athletes following muscle fatigue



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ABSTRACT

Scapular kinematics alterations have been found following muscle fatigue. Considering the importance of the lower trapezius in coordinated scapular movement, this study aimed to investigate the effects of elastic taping (Kinesio taping, KT) for muscle facilitation on scapular kinematics of healthy overhead athletes following muscle fatigue. Twenty-eight athletes were evaluated in a crossover, single-blind, randomized design, in three sessions: control (no taping), KT (KT with tension) and sham (KT without tension). Scapular tridimensional kinematics and EMG of clavicular and acromial portions of upper trapezius, lower trapezius and serratus anterior were evaluated during arm elevation and lowering, before and after a fatigue protocol involving repetitive throwing. Median power frequency decline of serratus anterior was significantly lower in KT session compared to sham, possibly indicating lower muscle fatigue. However, the effects of muscle fatigue on scapular kinematics were not altered by taping conditions. Although significant changes were found in scapular kinematics following muscle fatigue, they were small and not considered relevant. It was concluded that healthy overhead athletes seem to present an adaptive mechanism that avoids the disruption of scapular movement pattern following muscle fatigue. Therefore, these athletes do not benefit from the use of KT to assist scapular movement under the conditions tested.

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1. Introduction

Overhead throwing places high forces in the shoulder muscles and ligaments due to the wide range of motion and high speed required, predisposing overhead athletes to shoulder injuries (Wilke et al., 2009). Proper scapular movement and control is essential to provide a stable basis for humeral movement and suggested to help in the transfer of kinetic energy produced in the trunk and lower limb muscles to the arm and the ball during throwing (Sciascia et al., 2012).

The actions of serratus anterior and lower trapezius form an important force couple for coordinated scapular movement. The serratus anterior produces scapular upward rotation, posterior tilting and external rotation (Phadke et al., 2009). The lower trapezius is a scapular external rotator, an important synergist of serratus anterior for scapular upward rotation, and promotes scapular medial stabilization (Johnson et al., 1994; Phadke et al., 2009). Decreased activity of lower trapezius has been found in overhead

athletes with impingement symptoms (Cools et al., 2004, 2007), which may be related to the increased scapular internal rotation and decreased upward rotation found during arm elevation in subjects with shoulder impingement (Ludewig and Reynolds, 2009). The lower trapezius and serratus anterior are highly active during the throwing movement (Escamilla and Andrews, 2009) and, therefore, predisposed to muscle fatigue during sports activities. Several studies have investigated the effects of muscle fatigue on scapular kinematics using protocols involving isometric push-up associated with scapular protraction (Borstad et al., 2009), repetitive shoulder external rotation and arm elevation tasks (Chopp et al., 2011; Ebaugh et al., 2006; Joshi et al., 2011). However, the alterations found in scapular kinematics varied depending on the task performed during the fatigue protocol. A fatigue protocol simulating overhead throwing could more accurately represent the scapular kinematics alterations caused by muscle fatigue in overhead athletes during sports practice.

Interventions able to decrease scapular movement alterations caused by muscle fatigue could potentially contribute to shoulder injury prevention in overhead athletes. Different taping techniques have been proposed aiming to assist scapular function and change muscle activation in the shoulder complex of healthy and injured

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subjects (Hsu et al., 2009; Lin et al., 2011; Shaheen et al., 2015; Van Herzele et al., 2013). It has been suggested that these techniques can be helpful for shoulder injuries prevention and rehabilitation in overhead athletes (Hsu et al., 2009; Van Herzele et al., 2013). Kinesio taping (KT) is a technique that uses an elastic adhesive tape which causes minimal movement restriction and continual skin traction, stimulating cutaneous mechanoreceptors, which has been suggested to drive a facilitatory effect to the muscle (Firth et al., 2010; Konishi, 2013).

A KT technique for scapular stabilization has been shown to increase scapular upward rotation and posterior tilt in healthy handball players (Van Herzele et al., 2013). In a study of baseball players with shoulder impingement, a KT technique for lower trapezius facilitation increased muscle activity during arm lowering and scapular posterior tilt during arm elevation (Hsu et al., 2009). These effects were considered positive, but it is unknown if they would also occur in healthy overhead athletes following muscle fatigue. Therefore, the purpose of this study was to investigate the effect of KT for lower trapezius facilitation on scapular kinematics and muscle activation of healthy overhead athletes following muscle fatigue induced by throwing. It was hypothesized that KT for lower trapezius could facilitate its action during throwing, consequently assisting serratus anterior function and minimizing scapular alterations following muscle fatigue. This effect could potentially contribute for shoulder injury prevention in the overhead athletes population.

2. Methods

This investigation used a repeated-measures, crossover, sham-controlled, randomized, single-blinded (subject) study design. Participants were evaluated in three sessions, in random order: control (no taping), KT (KT with tension) and sham (KT without tension). There was one-week interval between sessions, in order to avoid cumulative effects of the taping (Hsu et al., 2009) and muscle fatigue (Myers et al., 1999).

2.1. Participants

Twenty-eight healthy overhead athletes (19 males and 9 females) with mean $\pm$ SD age 20.7 ± 2.5 years, mean height 172 ± 11 cm and mean body mass 71 ± 14 kg, volunteered after giving their informed consent. Inclusion criteria were participation in regular sports training (at least three times per week) and no symptoms involving the shoulder. Exclusion criteria were shoulder injuries in the last year, previous shoulder surgery, shoulder dislocation, and the performance of upper-body exercises in the 24 h prior to each evaluation session. The included athletes were involved in regular training of handball ($n = 20$), baseball ($n = 4$)

or softball ($n = 4$) on average 5.5 ± 3.9 years and participated in university-level competitions. This study was conducted in agreement with the declaration of Helsinki and approved by the Ethics Committee of the University.

2.2. Instrumentation

Surface EMG data were collected using an 8-channel Bagnoli EMG System (DelSys, Boston, USA), which provided voltage gain of 1000, bandwidth of 20–450 Hz and noise ≤ 1.2 μ V (RMS). Active double differential electrodes (#DE 3.1, DelSys, Boston, USA), with three parallel bars (1 mm $\times$ 1 cm) geometry, 1 cm of distance between the contacts, composed of 99.9% Ag were used. The electrodes had input impedance of 10^{15} ohms in parallel, with 0.2 pF; common mode rejection ratio of 92 dB; noise ≤ 1.2 μ V (RMS); and preamplifier gain of 10. The EMG system was interfaced with a computer via a 16-channel, 12-bit A/D card (Computer Boards, Inc., Middleboro, MA) and recorded using the MotionMonitor software (Innovative Sports Training, Chicago IL, USA). The sampling rate was set at 2000 Hz per channel. Three-dimensional kinematics of the thorax, scapula and humerus were collected at 100 Hz with the Flock of Birds electromagnetic tracking system (Ascension Technology Corporation, Burlington, VT) integrated with the Motion Monitor software.

2.3. Procedures

2.3.1. Three-dimensional kinematics and EMG acquisition

The EMG signal was collected from the clavicular and acromial portions of upper trapezius, lower trapezius and serratus anterior of the dominant arm. The electrodes were positioned parallel to the length of the along muscle fibers, in the sites described in Table 1. Before electrode positioning, the skin was shaved and cleaned with alcohol in order to reduce resistance and ensure good signal conduction. A reference electrode was positioned on the contralateral wrist. Initially, EMG signal was recorded at rest, with the subjects sitting on a chair, with the arms relaxed at the trunk side and the head in neutral position, during 5-s. Maximal voluntary isometric contractions (MVIC) were performed in order to determine the peak EMG to be used for signal normalization. Three MVIC of 5 s of duration each, with 30-s interval between them were performed for each muscle portion, in the positions described in Table 1.

The sensors for three-dimensional kinematics evaluation were fixed on anatomical landmarks. The first sensor was placed on sternum, just inferior to the sternal notch, the second one on the flat surface of the posterior acromion process, and the third one was fixed on a thermoplastic cuff and attached to the distal humerus. A fourth sensor was attached to a stylus and used to palpate and digitize the anatomical landmarks, in order to determine the

Table 1

Electrode position and maximal voluntary isometric contractions (MVIC) tests for each muscle portion evaluated.

Muscle portion	Electrode position	MVIC test
Acromial portion of upper trapezius	Midway between C7 spinous process and the acromion (Hermens et al., 2000)	Seated position, dominant arm at 90° of abduction, head rotation to the opposite side and ipsilateral lateral flexion. Resistance was applied against shoulder abduction and head lateral flexion (Ekstrom et al., 2005; Zanca et al., 2014)
Clavicular portion of upper trapezius	20% lateral to the midpoint between C3 and the most lateral point of the clavicle (Zanca et al., 2014)	
Lower trapezius	2/3 on the line from scapular root spine and T8 spinous process (Hermens et al., 2000)	Prone position, with the arm in abduction, aligned with the muscle fibers. Resistance was applied in the direction of the floor (Ekstrom et al., 2005)
Serratus anterior	On the level of xiphoid process, in the lateral trunk, in a 45° angle from anterior to posterior direction (Anders et al., 2004)	Seated position, arm at 90° of flexion and resistance applied against scapular protraction (Ekstrom et al., 2005)

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