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Comparison of exercises inducing maximum voluntary isometric contraction for the latissimus dorsi using surface electromyography

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ABSTRACT

The aim of this study was to compare muscular activation during five different normalization techniques that induced maximal isometric contraction of the latissimus dorsi. Sixteen healthy men participated in the study. Each participant performed three repetitions each of five types of isometric exertion: (1) conventional shoulder extension in the prone position, (2) caudal shoulder depression in the prone position, (3) body lifting with shoulder depression in the seated position, (4) trunk bending to the right in the lateral decubitus position, and (5) downward bar pulling in the seated position. In most participants, maximal activation of the latissimus dorsi was observed during conventional shoulder extension in the prone position; the percentage of maximal voluntary contraction was significantly greater for this exercise than for all other normalization techniques except downward bar pulling in the seated position. Although differences in electrode placement among various electromyographic studies represent a limitation, normalization techniques for the latissimus dorsi are recommended to minimize error in assessing maximal muscular activation of the latissimus dorsi through the combined use of shoulder extension in the prone position and downward pulling.

1. Introduction

In most electromyographic (EMG) studies, EMG normalization is performed by expressing the EMG amplitude relative to that of a maximal or submaximal voluntary contraction (Burden, 2010). Normalized EMG activity is used to compare activity levels among subjects and exercises. Without the use of an appropriate normalization method, however, EMG amplitude values may exceed 100% maximal voluntary contraction (MVC), despite the “maximal” nature of this measurement (Youdas et al., 2010; Hautier et al., 2000). The use of different normalization methods and electrode placement sites has limited the comparability of previous findings. Although some studies have established normalization techniques for specific muscles, research on this is lacking, so that electromyography (EMG) and manual muscle tests are generally used (Kendall et al., 2005; Hislop and Montgomery, 2002; Cram et al., 1998).

Several studies have sought to identify appropriate normalization methods for muscles of the upper extremity (Boettcher et al., 2008; Ekstrom et al., 2005; Smith et al., 2004). Ekstrom et al. (2005) compared various normalization methods for the serratus anterior and upper and lower trapezius muscles, and Smith et al. (2004) investigated rhomboid muscle EMG activity during three different manual muscle tests. Although these two studies identified appropriate normalization methods for the scapulothoracic musculature, no similar finding has been reported for other muscles, such as the latissimus dorsi (LD). To our knowledge, only two studies have investigated normalization methods for the latissimus dorsi (LD) using specific shoulder and trunk movements (Vera-Garcia et al., 2010; Boettcher et al., 2008). Vera-Garcia et al. (2010) compared 11 maximum voluntary contraction (MVC) techniques for the trunk musculature in healthy young females, but they excluded movements such as shoulder extension and depression, which are also important components of shoulder movement. Boettcher et al. (2008) investigated standard MVC techniques for shoulder muscles, including the LD, but excluded trunk bending movements. Although both studies found an appropriate MVC method related to specific trunk and shoulder movements and provided useful recommendations for researchers, normalization techniques for the LD still need to be investigated, due to its characteristics.

The LD is a very broad muscle that arises from the lower six thoracic vertebrae, lumbodorsal fascia, sacrum, and iliac ala; along with the teres major, it inserts on the medial edge of the bicipital sulcus of the humerus (Cram et al., 1998). This muscle contributes to shoulder adduction, internal rotation, and extension, and it directly connects the upper extremity and trunk. Because of its importance, researchers have investigated several exercise meth-

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ods and instruments to activate the LD (Youdas et al., 2010; Koyama et al., 2010; Snyder and Leech, 2009; Lehman et al., 2004). However, the use of different normalization methods in assessments of the same exercises has limited the ability to interpret results. For instance, for a lat pull-down (LPD) exercise using the same load, Koyama et al. (2010) investigated the effects of freedom of movement on LD activation and reported almost 50% MVC, whereas Snyder and Leech (2009) reported almost 70% MVC.

Various methods of determining the MVC of the LD have been used for healthy and diseased individuals (Hislop and Montgomery, 2002; Kendall et al., 2005; Signorile et al., 2002). Shoulder extension in the prone position (EP) is a widely used manual muscle test (Hislop and Montgomery, 2002; Kendall et al., 2005). Prone shoulder depression and body lifting in the seated position (BL) have been used to independently activate the LD (Hislop and Montgomery, 2002). Lateral bending of the upper trunk in the lateral decubitus position (UTB) has also been recommended (Vera-Garcia et al., 2010). Most recent studies have used isometric pull-down exertion with the shoulder abducted to 90° and the elbow flexed to 90° (Snyder and Leech, 2009; Lehman et al., 2004).

No previous study has compared these methods for the normalization of LD activity. Therefore, the main purpose of this study was to assess the LD muscle activity in five exercise positions used to measure the MVC by EMG. A secondary purpose was to determine an appropriate normalization method from these five MVC positions for LD muscle assessment.

2. Materials and methods

2.1. Subjects

Sixteen males were recruited from the local university using convenience sampling. For participant homogeneity, healthy right-arm dominant males with a body mass index (BMI) ⩽25 were included in this study. Subjects with a history of upper- or lower-extremity injury within 6 months were excluded. Before conducting the experiments, a pilot study was performed to identify any limitation in the range of motion of the upper extremity and shortness of the latissimus dorsi. Participants ranged from 21 to 24 years of age, mean height was 178.1 ± 5.6 cm, mean weight was 69.6 ± 8.5 kg, and the mean BMI was 21.8 ± 1.8 kg/m^2. The ethics committee of the University of Inje approved this study, and all volunteers gave written informed consent before participation.

2.2. Electromyography

A Trigno wireless system (Delsys, Boston, MA, USA) was used to obtain EMG signals. A single-channel surface electrode was placed at an oblique angle (∼25°) over the LD muscle on the dominant (right) side, approximately 4 cm below the inferior tip of the scapula and midway between the spine and lateral edge of the torso (Cram et al., 1998). The electrode was placed on the abdominal muscle site after inducing shoulder adduction, extension, and internal rotation in a seated position. Although one researcher placed the electrodes on all participants, the sites used differed among participants due to adduction, extension, and internal rotation. We placed the electrodes on abdominal muscle sites adjacent to those confirmed by geometric measurements. The skin site was initially prepared by shaving and abrasion, followed by cleaning with an alcohol swab to reduce impedance. The Trigno electrode used in this study has a band pass of 20–450 Hz and a common-mode rejection ratio of 80 dB. The researchers controlled data acquisition and processing on a laptop computer using EMG-Works software (Delsys Boston, MA, USA). Data were collected at a sampling rate of 2000 Hz and processed at 0.125-s intervals using the root mean square method.

2.3. Experimental procedures

Resting EMG activity was recorded while the subject lay in a relaxed prone position. The participant was then asked to perform three trials of five isometric exertions believed to effectively activate the LD. Prior to testing, the participant was given 1 min of practice time for each exercise set.

All exercises were performed for 5 s against manually applied resistance while the data were recorded, with a minimum 30-s rest between contractions. The participants rested for 5 min between exercise sessions. The order of exercise execution was randomized among participants. The five isometric exertions are described below (Fig. 1).

(1) EP (Kendall et al., 2005; Hislop and Montgomery, 2002; Youdas et al., 2010): the participant lay prone on a bench with his arms by his sides and the shoulders internally rotated to create a palm-up position. From this position, the participant tried to move his shoulder toward the ceiling (extension). Downward manual resistance was applied to the forearm, and pressure was exerted on the contralateral side of the pelvis.

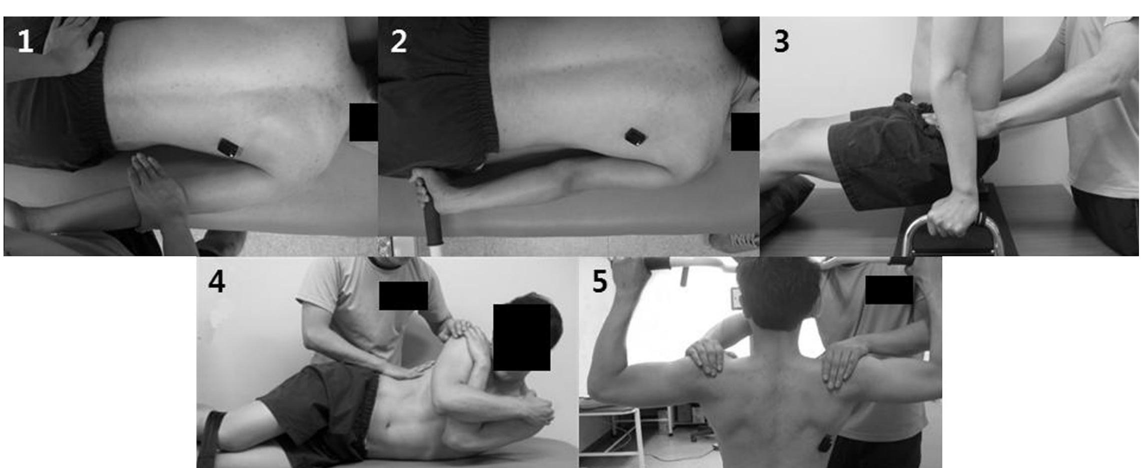

Fig. 1. The five exercises aimed at maximally activating the latissimus dorsi muscle. (1) Extension in Prone (EP), (2) caudal depression (CD), (3) body lifting (BL), (4) upper trunk bending (UTB), (5) Lat pull down (LPD).