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ELECTROMYOGRAPHIC VALIDATION OF THE *TRAPEZIUS* AND *SERRATUS ANTERIOR* MUSCLES IN PULL-OVER EXERCISES

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ABSTRACT

The electromyographic activity of the *trapezius* and *serratus anterior* muscles was studied in 24 male volunteers during pull-over exercises. In 54.2% of the cases, the activity of the *trapezius* varied from weak to strong. In the remaining cases, as well as in pull-overs done with the arms bent, this muscle was inactive. Thus, the *trapezius* acts preferentially in pull-overs, but its variable levels of activity do not justify its inclusion in programs of physical conditioning. The *serratus anterior* had levels of activity which varied from weak to very strong in pull-over exercises. In pull-overs with bent arms, this muscle showed very strong activity in almost half of the cases, thus justifying its inclusion in basic exercises in programs for physical conditioning. When conditioning the *serratus anterior* muscle using pull-over exercises with bent arms, the execution should not exceed the half way point of the return movement.

Key words: Electromyography, exercises, physical conditioning, *serratus anterior, trapezius*

INTRODUCTION

Few electromyographic studies have described the involvement of the *trapezius* and *serratus anterior* muscles in pull-over exercises. O'Shea [11] examined the role of the *serratus anterior* muscle, and Ferreira *et al.* [4,5] analyzed the participation of the *deltoideus* and *pectoralis major* muscles in other types of exercises during physical conditioning.

In the present study, we assessed the involvement of the *trapezius* and *serratus anterior* muscles in pull-over exercises in order to determine whether these exercises should be recommended for inclusion in programs of physical conditioning.

MATERIAL AND METHODS

The upper portion of the *trapezius* muscle (TS) and the lower portion of the *serratus anterior* muscle (SI) were studied in 24 healthy male volunteers, 18 to 25 years old, who had no previous technical sport training.

The electromyographic analysis was done using a two-channel TECA TE 4 electromyograph set at 500 µV and a paper speed of 370 ms/division. Two pairs of Hewlett Packard surface electrodes greased with electroconductor gel were used. One of the electrodes was placed at the mid point of the cephalic border of the upper portion of the *trapezius* muscle and the other at the sixth digitation of the *serratus anterior*, close to the posterior axillary pleat. Prior to electrode positioning, the skin was depilated and cleaned with 70% ethanol. The electrodes were connected to the electromyograph through pre-amplifiers.

The volunteers were duely "grounded" with a metal plate greased with electroconductor gel and fixed to the left wrist using a retention belt. All electromyographic tests were done in an electrostatic "cage" to avoid external interferences.

The subjects were trained to do the exercises correctly before the study. The exercises, which included a full pull-over and a pull-over with bent arms, both using a middle grip, were done on a regulatable supine bench fitted with a wooden bar 1.2 m long. The exercises were done as described by Machado [10] with the posture being strictly controlled. The data were scored using the method of Basmajian [1], with the following degrees of intensity: inactivity (-), weak activity (+), moderate activity (2+), strong activity (3+) and very strong activity (4+). The results were tabulated as the median (M) and the first and third quartiles (Q1 and Q3) for each group. The responses of the two muscles in each type of exercise were compared using the Wilcoxon non-parametric test [13] for two paired samples. A value of $p<0.05$ indicated significance.

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RESULTS

The electromyographic results for the *trapezius* and *serratus anterior* muscles are shown in Figures 1 and 2, along with a summary of the pattern of execution. The electromyographic records are shown schematically for the several phases of the exercises. Note that the height of the line representing the electromyographic profile does not correspond directly to the action potential amplitude.

Figure 3 shows the activity scores for the two muscles in the pull-over exercises. The statistical comparisons of the two forms of execution are summarized in Table 1.

DISCUSSION

During pull-over exercises, the individual positioned with the arms flexed at 90º executes a flexion initially at 180º and, when returning to the

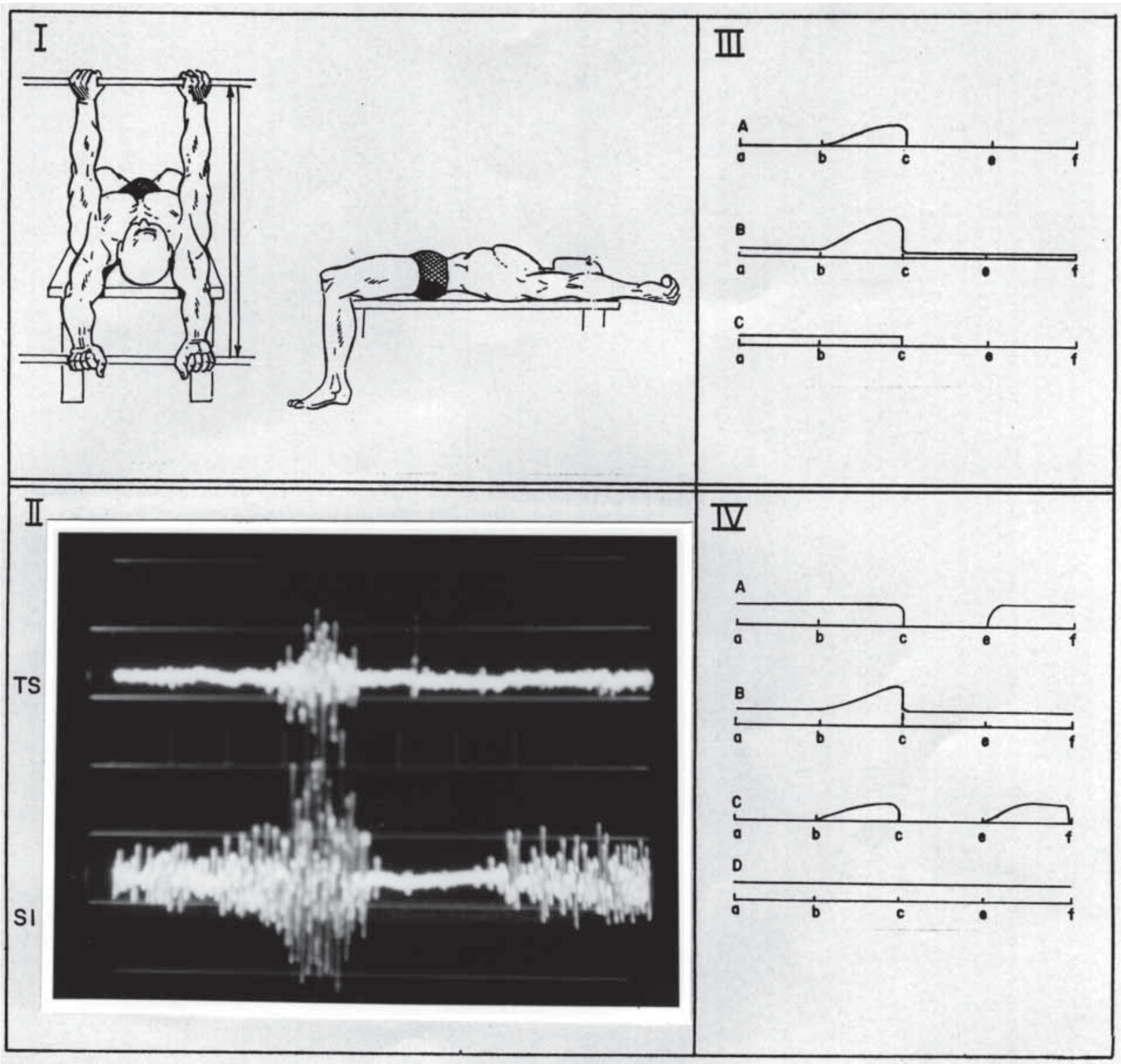

Figure 1. Pull-over exercise with middle grip. **I.** Representation of the executed movement. **II**. Electromyograph of the upper portion of the *trapezius* (TS) and lower portion of the *serratus anterior* (SI) muscles with activity scores of (+) for TS and (3+) for SI. Calibration (C) = 200 μV; and the recording speed was 370 ms/div. **III, IV.** Schematic representation of the electromyographic profiles. For TS (**III**): (A), (B) and (C) correspond to 69.2%, 23.1% and 7.7% of cases, respectively. For SI (**IV**): (A), (B), (C) and (D) correspond to 33.3%, 29.2%, 25% and 12.5% of cases, respectively.

initial position, the arms and the elbow articulation are extended (Fig. 1). In the pull-over exercise with bent arms, the articulation of the elbow is flexed, despite the flexion and extension of the arms (Fig. 2).

In pull-overs and pull-overs with bent arms, the *trapezius* was practically inactive. In those cases in which it was active, the level of activity varied from weak to strong in pull-overs, and from weak to moderate in pull-overs with bent arms. The potentials that were recorded appeared only in the last half of the flexion phase, probably because the individual was performing the flexion in the direction of gravity. Others [2,3,7-9,12] have reported that in flexion of the arm at 180º done with the individual standing, the amplitude of the action potentials of the *trapezius* increases throughout the movement.

The *serratus anterior* had a greater participation in these exercises, with very strong action potentials in almost half of the pull-over exercises with bent arms; in the other cases, the activity was

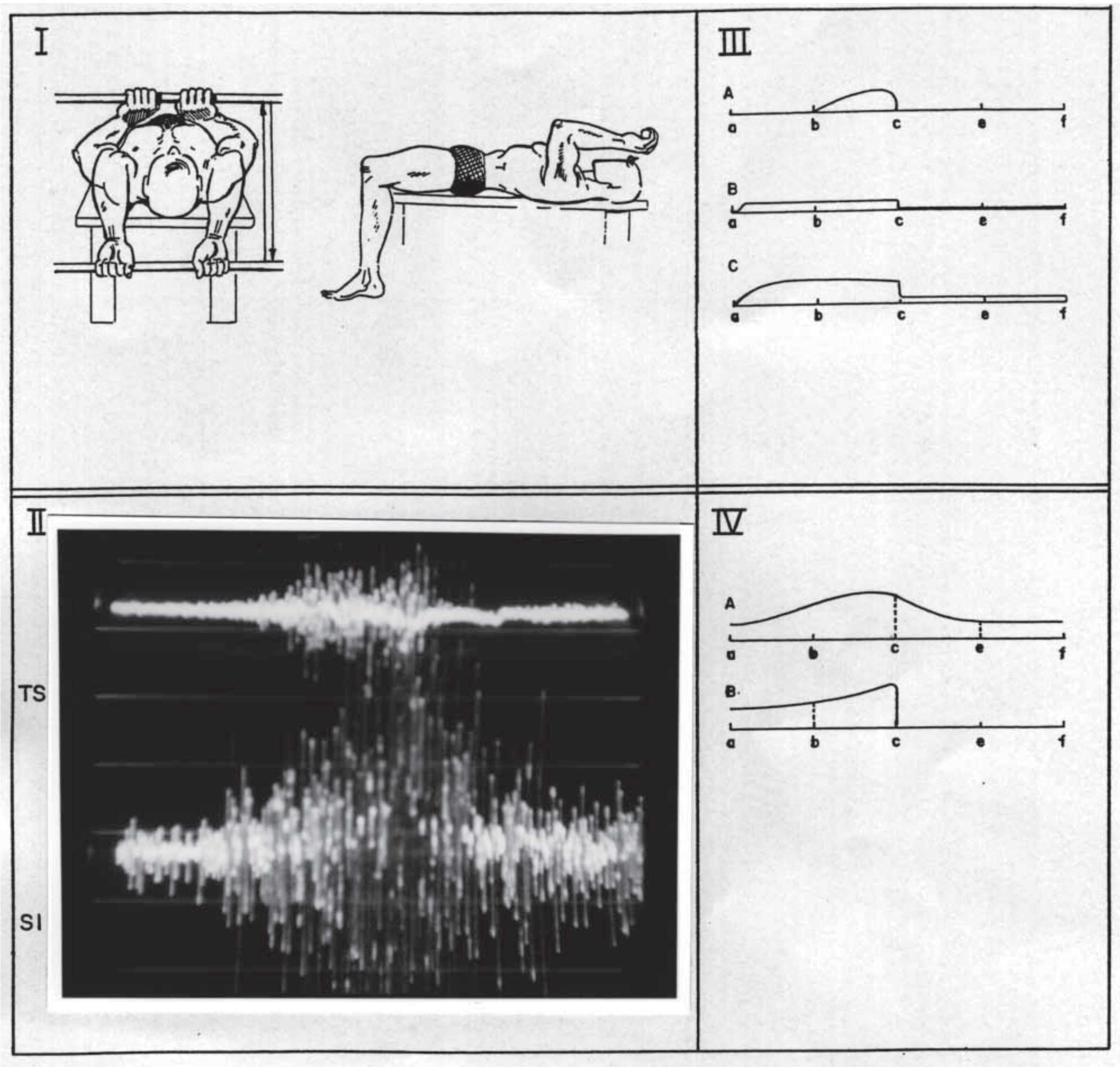

Figure 2. Pull-over exercises with bent arms and middle grip. **I**. Representation of the executed movement. **II**. Electromyograph of the upper portion of the *trapezius* (TS) and lower portion of the *serratus anterior* (SI) with activity scores of (2+) for TS and (4+) for SI. Calibration (C) = 200 µV; and the recording speed was 370 ms/div. **III, IV.** Schematic representation of the electromyographic profiles: For TS (**III**): (A), (B) and (C) correspond to 50%, 37.5%, 12.5% of cases, respectively. For SI (**IV**): (A) and (B) correspond to 70.8%, and 29.2% of cases, respectively.

Table 1. Medians (M), first and third quartiles (Q1 and Q3) and statistical results for the electromyographic variables of the *trapezius* (upper portion) and *serratus anterior* (lower portion) in each modality of pull-over exercises with middle grip.

Muscle	Parameter	Modality		Statistical result
		Pull-over	Bent arms	
Trapezius	M	1.0	0.0	W = 59
	(Q1, Q3)	(0.0, 1.5)	(0.0, 1.0)	($p<0.05$)
Serratus anterior	M	2.5	3.0	W = 123
	(Q1, Q3)	(2.0, 3.0)	(3.0, 4.0)	($p<0.05$)

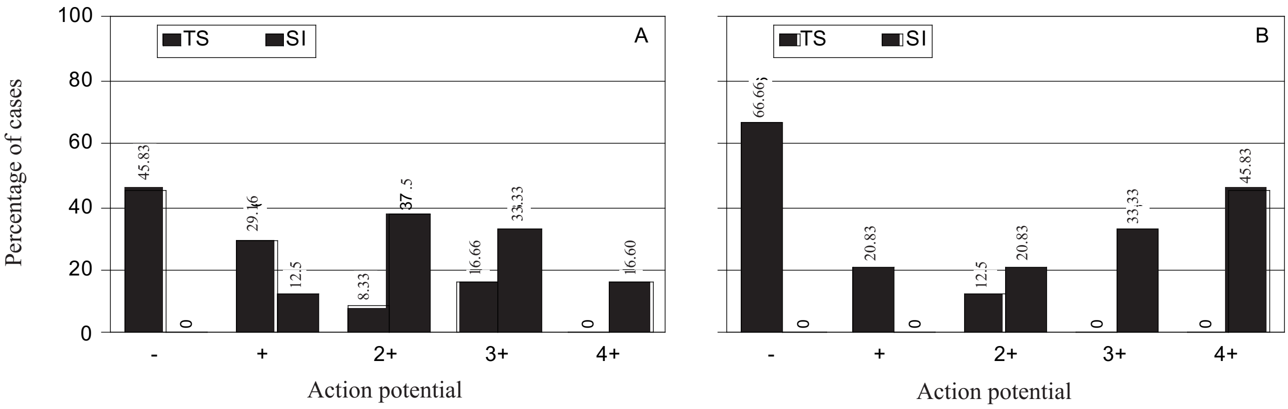

Figure 3. Frequency of the intensities of muscle contraction in the *trapezius* (upper portion) and *serratus anterior* (lower portion) muscles in pull-over movements executed with a middle grip. **A.** Pull-over exercises. **B**. Pull-over exercises with bent arms. The columns represent the mean percentage of the number of volunteers studied (n=24).

moderate or strong. In pull-over exercises with flexed arms the frequency of action potentials was lower, although they were of the same amplitude as in the other exercises. This muscle was electrically silent between the end of the first phase (flexion of the arms) and the middle of the second phase (extension of the arms). According to Büll *et al*. [2], the *serratus anterior* muscle is active in flexion and extension movements of the arm, with an electromyographic profile that increases then decreases. These characteristics were observed only in pull-over exercises with bent arms when the flexed articulation of the elbows and the hands positioned in the mid-sagittal plane tended to hinder execution of the movement.

The *trapezius* was activated significantly more in pull-over exercises than in pull-overs with bent arms, whereas the opposite was true for the *serratus anterior*.

In contrast to the negative conclusions of O'Shea [11] regarding the usefulness of the pull-over exercise for the *serratus anterior* muscle, we recommend the inclusion of this exercise in programs of physical conditioning. Based on the electromyographic profile of this muscle, we suggest that the execution of this exercise should not exceed the half waypoint of the return movement in order to prevent excessive relaxation of the muscle.

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