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Electromyograph of the Pectoralis Major Muscle after Surgical Reconstruction of Chronic Tendon Rupture

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Conflict of Interests
The authors have no conflict of interests to declare.

INTRODUCTION

Rupture of the pectoralis major (PM) muscle has become increasingly common due to the association among gym use, use of anabolic steroids and the male sex (there are no reports of PM rupture in females).[1,2] In the case of gym users or athletes, the chronic stages of PM injury may result in significant loss of adduction (from 10% to 50%) and important cosmetic deformity of the hemithorax.[3–14]

Surgical treatment has been recommended in these patients to reestablish function and esthetics.[2]

Even with good clinical and functional outcomes during the postoperative period of PM tendon surgery, questions have persisted about the electrophysiological activity of the injured muscle.

Electromyography (EMG) enables the extracellular re- cording of the bioelectric activity generated by muscle fibers.

Thus, this method plays an important role in illustrating the electrophysiological profile of injured and reconstructed muscles at the time of examination, and assists in the evolution during physiotherapy and return to sports. The present study aimed to evaluate the PM of operated patients who perform weightlifting, more specifically bench-press exercises, especially the activity of the clavicular and sternocostal portions of the PM.

Although this type of evaluation is increasingly being used in clinical care and scientific research, a consensus on several aspects of the method is lacking. The sensor placement, the number of contractions of phasic fibers, the time of contraction of tonic fibers, the need for concomitant evaluation of synergistic muscles, as well as the possibility of use in special situations should still be standardized.

MATERIALS AND METHODS

Study Population

We analyzed 20 weightlifters who were previously registered and treated at the Sports Traumatology-Orthopedics Center, according to the Brazil Platform CAAE number 20959813.0.0000.5505.

All athletes in study I (10 patients) had unilateral complete ruptures during bench-press exercises and a history of anabolic steroid use, an association that is described in up to 86.7% of PM tendon ruptures. The control group included ten resistance exercise practitioners without PM tendon injury who did not perform bench-press exercises. The individuals were required to sign an informed consent form.

Inclusion Criteria

Study I

Case Group

This group included ten individuals who were already being monitored at the Sports Medicine outpatient facility, had a history of PM tendon rupture and surgical reconstruction following the standard protocol,[14] performed bench-press exercises at least three times a week pre-injury, had more than ten years of competitive weightlifting experience in bench press, and had a history of anabolic steroid use.

Control Group

This group included ten individuals who were matched regarding gender and age to the case group, and they led sedentary lifestyles or practiced sports sporadically, and had no history of anabolic steroid use.

Exclusion Criteria

Study I excluded individuals with PM tendon injury occur- ring during sports other than weightlifting, individuals without a history of steroid use, and athletes with a history of chronic disease such as diabetes, nephropathy or other diseases that are known to present with tendinopathy.

MATERIALS AND METHODS

Clinical Evaluation

All subjects answered a specific questionnaire evaluating the period of time that they had been performing weightlifting and their use, type and frequency of use of anabolic steroids in the previous 12 months. On average, patients with chronic PM injury had a 5.5-month waiting period between injury and PM reconstruction surgery with the same operatory technique.[11] The surgical technique used was previously described in our studies,[14] and the rehabilitation protocol used was also standard for this type of injury and surgery.

Electromyography

Visits to the Sports Traumatology-Orthopedics Center were scheduled by phone call, and the individuals underwent EMG, which was collected dynamically using a MegaWin 3.1, ME-6000 T-8-channel, version 3.0, with a system with a calibration frequency of 2,000 Hz, high pass filter of 20 Hz, and low pass filter of 500 Hz.

Disposable, adhesive, passive, monopolar Meditrace electrodes (DBI Medical, São Paulo, SP, Brazil) were used, with solid gel, silver/silver chloride (Ag/AgCl), a capture area of 1 cm, and a distance of 2 cm between the electrodes. The patients were analyzed during bench-press exercises and underwent EMG following the validated protocol, in which electrodes were placed based on tape measurements from the collarbone to the xiphoid process, considering 60% of this length as the PM muscle area. After determining this value, 80% of the width of the PM was calculated by measuring the insertion of the PM from the humerus to the sternum. The result for the 80% of the width was considered the central point, and 1 electrode was placed on each side of this central point following the direction of the muscle fibers on the dominant side. The ground electrode was placed on the medial epiphysis of the clavicle on the dominant side.

The athletes performed a maximum series of each exercise with a load equivalent to the 10-repetition maximum. The order of the exercises was randomized among the individuals. The exercise was performed using the Olympic Bench Press equipment from the FW line. The practitioners were instructed to perform the eccentric phase by directing the bar in a line near the center of the sternum without touching the chest to avoid electrode movement.

A total of twenty athletes were selected for electromyographic measurement in the bench press exercise to evaluate the recruitment of the two main portions of the PM muscle during exercise performed in the postoperative period of PM tendon reconstruction using flexor tendon grafts.

All chronic patients were evaluated by electromyography five months postoperatively.

MATERIALS AND METHODS

Table 1 Measurements of the clavicular and sternocostal portions of the pectoralis major muscle obtained by electromyography in healthy controls and in weightlifters after surgery on the operated and contralateral sides

	Groups			*p*-value	
	Control (C)	Postoperative: operated side (POS)	Postoperative: contralateral side (POCL)	C x POS	POS x POCL
Clavicular					
Average level	293.2 (200.0, 386.3)	273.8 (99.7, 447.8)	203.7 (99.6, 307.7)	0.847	0.058
Standard deviation	104.9 (70.3, 139.5)	96.1 (46.1, 146.1)	72.4 (35.3, 109.6)	0.777	0.002
Area	7,481.4 (4,896.9, 10,065.9)	7,743.2 (2,230.2, 13,256.2)	5,773.1 (2,429.0, 9,117.2)	0.933	0.09
Median	269.9 (174.5, 365.2)	266.0 (76.4, 455.6)	194.7 (90.2, 299.2)	0.972	0.109
Sternocostal					
Average Level	345.0 (204.0, 486.0)	304.4 (216.0, 392.9)	233.2 (160.3, 306.2)	0.633	0.121
Santadard deviation	119.0 (71.3, 166.6)	103.6 (70.7, 136.4)	92.8 (53.0, 132.5)	0.602	0.554
Area	8,314.2 (4,778.2, 11,850.2)	8,125.7 (5,707.6, 10,543.8)	6,471.4 (4,200.6, 8,742.3)	0.931	0.126
Median	335.9 (187.8, 484.0)	292.4 (193.4, 391.5)	215.2 (143.7, 286.8)	0.633	0.091

Notes: The data are expressed in μV as means of estimates and 95% confidence intervals; *p*: multiple comparisons between groups.

RESULTS

Measurements of the clavicular and sternocostal portions of the PM muscle were obtained using bilateral EMG in weight- lifters and controls to compare the groups; the right and left sides were considered replicate measurements of a subject.

One patient was lost during the postoperative period because he did not return for the five-month follow-up evaluation.

Of the patients who underwent surgery, 9 weightlifters who performed bench-press exercises, had unilateral injuries, and a mean age of 36.7 years (SD=9.1 years) were evaluated. Nine control patients were analyzed for a homogeneous sample of patients between the C group and nine cases. Additionally, nine control patients were evaluated. The measurements were obtained by EMG on the injured sides subjected to reconstruction of the PM with a flexor tendon graft (postoperative operated side [POS] group: nine measurements) and on the sides contralateral to the operated sides (postoperative contralateral side [POCL] group: nine measurements).

Comparisons between the groups were performed by fitting models considering the dependence between the bilateral measurements of the same individual.

In the comparison between the C and POS groups, we found no evidence of differences (Table 1) in any measurements obtained in the clavicular and sternocostal portions of the PM muscle: clavicular average level ($p=0.847$); clavicular SD ($p=0.777$); clavicular area (p 1⁄4 0.933); clavicular median ($p=0.972$); sternocostal average level ($p=0.633$); sternocostal SD ($p=0.602$); sternocostal area ($p=0.931$) and sternocostal median ($p=0.633$).

DISCUSSION

The frequency of PM muscle injuries has led to studies on the ability of the repaired or surgically-reconstructed PM muscle to return to adequate functional activity.[2–15]

Isokinetic assessment using torque peak and muscle work in horizontal adduction has been very helpful in obtaining a more objective, albeit indirect, evaluation of PM muscle strength both in the pre- and postoperative periods of chronic injuries that require PM reconstruction. In general, after improvement, the level of muscle strength should normally exhibit a deficit of no more than 15% of that of the contralateral muscle. However, is this improvement due to recruitment of the activity of muscle parts other than the most injured sternocostal portion? The present study helps to better understand these functional aspects during the postoperative period in these patients.

One of the main variables analyzed by EMG is the maxi- mum voluntary contraction (MVC), which is performed by fast-twitch (type II) muscle fibers and is responsible for muscle strength.[1]

In athletes undergoing PM reconstruction, the EMG activity of the PM muscle was not different between the injured and contralateral sides, which may indicate that the reconstructed muscle has a functional capacity to assist in weight- lifting activities. Studies on pathological anatomy have shown no significant muscle degeneration, even in chronic cases, at two to five years after a PM injury.

The greater EMG activity on the operated side in the clavicular portion compared to the contralateral portion may be related to the attempt of the muscle portion not affected by the rupture to assist the injured sternocostal portion. Thus, a variance in functional improvement is observed.

DISCUSSION

These patients were not subjected to isokinetic assessment because the recovery of the strength level between five months and one year after surgery has been well established in other studies published by our research group and other authors. Muscle recovery is obviously variable, but, on aver- age, it enables a sufficient return to competitive activity.

As described, the main objective of the present study was to examine the electrical and functional activity of muscle contraction of the injured musculature and the musculature of the clavicular region. On average, the waiting period was of 5.5 months between injury and PM reconstruction surgery.

All chronic patients were evaluated by EMG five months postoperatively.

It is possible that the time between the EMG, the injury or the postoperative exam may have some impact on the results. In the present study, the average time between the injury and the surgery was of 5.5 months. The EMGs were performed every five months after surgery.

CONCLUSION

In the present study, the electromyographic activity of the PM muscle in weightlifters (bench-press exercise) who underwent surgery was within normal parameters for the clavicular and sternocostal portions studied.

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