Original article

Electromyographic validation of the muscles deltoid (anterior portion) and pectoralis major (clavicular portion) in military press exercises with middle grip

Bull, ML.[1]*, Ferreira, MI.[2] and Vitti, M.[3]

[1]Department of Anatomy, Instituto de Biociências, São Paulo State University – UNESP, Campus de Botucatu, Botucatu, CEP 18618-000, SP, Brazil
[2]Department of Anatomy, University Center Moacyr Sreder Bastos, Rio de Janeiro, RJ, Brazil
[3]Department of Morphology, Stomatology and Physiology, University of São Paulo – USP, Ribeirão Preto, SP, Brazil
*E-mail: marilena@ibb.unesp.br

Abstract

With the objective to know the electromyographic activity normal parameters of the deltoid (anterior portion) and pectoralis major (clavicular portion) muscles in the different modalities of military press exercises with middle grip, we analyzed 24 male volunteers using a two–channel electromyograph TECA TE 4, and Hewllet Packard surface electrodes. It was observed high inactivity levels for PMC in almost all the modalities and the concentration in the active cases, mainly, in the weak potential, while DA presented very high levels of much strong action potentials in all the modalities assessed.

Keywords: electromyography, muscle deltoid, muscle pectoralis major, physical conditioning, exercises.

1 Introduction

A great number of researchers used the electromyography to base aspects of muscular work not only in free joint movements, but also in movements executed from specific postures required by some professions as well some sportive modalities. In sportive medicine, such technique has helped the adaptation of exercise sequence to each subject due to variables such as individual abilities, bio-typology, technical capacity, among others.

However, literature by O'Shea (1976), Machado (1980) and Lambert (1987), treats the anatomical knowledge direct application to the physical conditioning work, not presenting scientific base under the light of electromyography for their recommendation.

Thus, we found the military press exercises indicated for the deltoid (O'SHEA, 1976; MACHADO, 1980; LAMBERT, 1987) and pectoralis major (O'SHEA, 1976) muscles conditioning.

These two muscular masses are currently considered as agonist pair in the muscular set in charge of the shoulder joint movement, responsible for the forward flexion and medial rotation of the arm (BASMAJIAN and DE LUCA, 1985; OKAMOTO, TAKAGI and KUMAMOTO, 1967; SCHEVING and PAULY, 1959; SOUSA, BERZIN and BERERDI, 1969).

The military press exercises execution involves the abduction/adduction performed during the bar lifting and lowering, respectively.

Thus, we analyzed several researches, mainly those of electromyographic nature, on the participation of the deltoid (anterior portion) and pectoralis major (clavicular portion) muscles in abduction and adduction movements. We found several authors who describe as active the anterior portion of the deltoid (SCHEVING and PAULY, 1959; PEAT and GRAHAME, 1977; SIGHOLM, HERDERTS, ALMNSTROM et al., 1984; CAMPOS, 1987; CAMPOS, VITTI and FREITAS, 1992; KAWANISHI, YAHAGI, SHIMURA et al., 1999), and the pectoralis major (SCHEVING and PAULY, 1959; RASCH and BURKE, 1977; BASMAJIAN and DE LUCA, 1985; WIRNED, 1986).

Other authors (SCHEVING and PAULY, 1959; WRIGHT, 1962; RASCH and BURKE 1977; DE LUCA and FORREST, 1973) mention the deltoid muscle as important shoulder stabilizer. The pectoralis muscle, specially the clavicular portion, was also considered responsible for shoulder stabilization in complex movements of a vehicle steering wheel (JONSSON and JONSSON, 1975) and pitching (JOBE, MOYNES, TIBONE et al., 1984).

However, it is not observed in most physical conditioning manuals used in Brazil, any coincidence with relation to basic exercises indication for these muscles conditioning.

No citation is done by Lambert (1987) about the pectoralis major clavicular portion participation during military press exercises performance. Also, no differentiation is done as for the participation of the three portions of the deltoid muscle. O'Shea (1976) characterizes the military press exercises as priority for the deltoid, superior portion, the pectoralis major and the grand dorsal conditioning. Machado (1980) recommends the use of these exercises, in a general way, for the scapular waist and arms muscles, predominating the requirement for the deltoid, although, he does not make any differentiation to each portion of this muscle.

Lambert (1987) characterizes the military press exercises in four modalities, i.e., sitting, laid, bent and standing. O'Shea (1976), however, cites only the standing and sitting modalities, while Machado (1980) indicates the forward and behind standing and sitting modalities

As for electromyographic studies on exercises used in physical conditioning programs, we found the rowing and cross exercises (PEDRO, 1992; FERREIRA, BÜLL and VITTI, 1995; 1996a,b; 2003a,b), and supine and frontal elevation (FERREIRA, BÜLL and VITTI, 2003c) studied in the deltoid and pectoralis major, while Rodrigues (2001) and Rodrigues, Büll, Dias et al. (2003) evaluated the flying exercise.

In previous works, we analyzed the military press exercises (BÜLL, FREITAS, VITTI et al., 2001a,b,c), as well the rowing (BÜLL, FREITAS, VITTI et al., 2002a,b,d; 2003), cross (BÜLL, FREITAS, VITTI et al., 2002c,d), pull-over (BÜLL, FREITAS, VITTI et al., 2002e) and the supine and frontal elevation (BÜLL, VITTI, FREITAS, et al., 2002f) for the trapezius ans serratus anterior muscles. Dias (2000) and Dias, Guazzelli, Rodrigues et al. (2003) worked on diving exercises, which are indicated for the strength development of the superior members muscles.

Thus, we decided to assess the electromyographic activity of the deltoid and pectoralis major muscles in several execution ways of military press exercises with middle grip, aiming at providing activity normal parameters, analyzing the most efficient modality, validating its inclusion in physical conditioning programs.

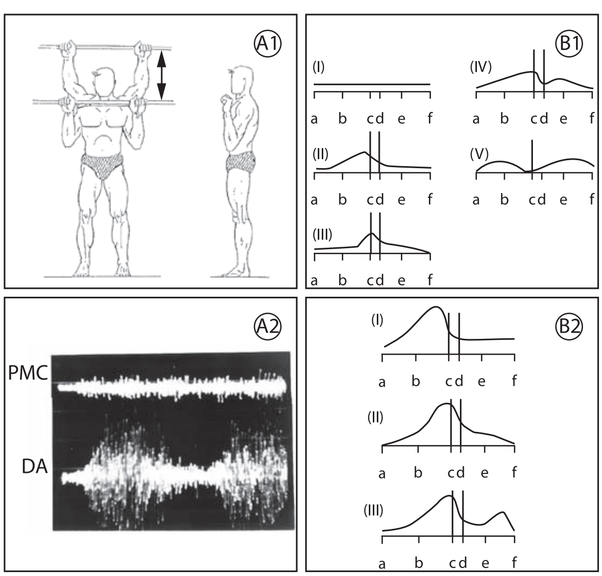

Figure 1. Movement of standing military press – forward – middle grip. A1) Representation of the movement executed. A2) Electromyograph of the pectoralis major – clavicular portion (PMC) and deltoid – anterior portion (DA). Activity levels: PMC (+) and DA (4+). Calibration (C) = 500 µV; velocity (v) = 370 ms/div. Schematic representation of electromyographic profiles: B1) Observed for PMC: I and II) 29.4% of the active individuals; III) 23.4% of active individuals; IV) 11.7% of active individuals and V) 5.8% of active individuals. B2) Observed for DA: I) 79.1% of active individuals; II) 16.6% of active individuals and III) 4.2% of active individuals; a = start position (hands upon thigh); b = middle point of bar elevation; c = maximum bar elevation; d = bar descent beginning; e = middle point of bar descent; f = return to start position.

2 Material and methods

Twenty-four male nonathletic subjects, 17 to 30 years old with no antecedents of muscular or joint injuries, were analyzed by using a two-channel TECA TE 4* electromyograph, routinely adjusted to 500 µV, with velocity of bundle displacement of 370 ms/division.

Hewlett Packard surface electrodes were connected to the pre-amplifiers of the electromyograph, using the superior channel for PMC and the inferior channel for the DA. Electrodes were placed after depilation and thorough cleansing, on the PMC 2,0 cm below the anterior border of clavicle along the longitudinal axis which crosses the middle point of the clavicle; and on the DA 4,0 cm below the clavicular insertion of the muscle along the longitudinal axis which crosses the middle point of that insertion.

All subjects were duly "grounded" with a metal plate greased with electroconductor gel and placed at the left wrist by using a retention belt.

For photographic documentation, it was used an Exa Thage Dresden camera with Isco-Gottingen Iscomar 1:2.8/50 mm

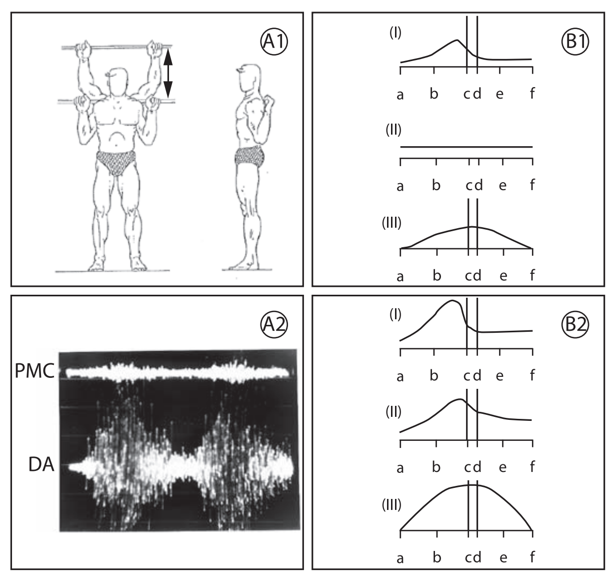

Figure 2. Movement of standing military press – behind neck – middle grip. A1) Representation of the movement executed. A2) Electromyograph of the pectoralis major – clavicular portion (PMC) and deltoid – anterior portion (DA). Activity levels: PMC (+) and DA (4+). Calibration (C) = 200 µV; velocity (v) = 370 ms/div. Schematic representation of electromyographic profiles: B1) Observed for PMC: I) 69.2% of the active individuals; II) 23.0% of active individuals and III) 7.7% of active individuals ; B2) Observed for DA: I) 79.2% of active individuals; II) 12.5% of active individuals and III) 8.3% of active individuals; a = start position (hands upon thigh); b = middle point of bar elevation; c = maximum bar elevation; d = bar descent beginning; e = middle point of bar descent; f = return to start position.

* The electromyographic equipment was obtained with grants from CNPq (Proc. 3834/70) and FAPESP (Proc. Med. 70/511) and donated to the Department of Morphology of the Faculty of Odontology of Piracicaba/UNICAMP.

objective loaded with KODAK TRI-X PAN (400 ISO) film, inside an electrostatic "cage" to avoid external interferences.

Before starting the data collect, the subjects were trained to perform each modality of military press exercises with middle grip: standing forward (StF); standing press behind neck (StB); sitting forward (SiF); sitting press behind neck (SiB).

To perform the exercises, the subjects used a regulating supine bench and a 120 cm long bar made of light wood. The execution form, with strictly controlled posture, was according to Machado (1980) pattern.

The electromyographic potential recorded was analyzed according to Basmajian (1978), expressing the following intensity levels: inactivity (–); low activity (+); moderate activity (++); high activity (+++) and very high activity (++++).

Statistical comparisons among these electromyographic records of the tested exercises were done by using the Friedman method and Wilcoxon test (RODRIGUES, 1975; LEVIN, 1987). The hypothesis that one of the exercises determines action potential levels significantly higher than another is accepted when $p < 0,05$.

3 Results

Figures 1-4 show the schematic representation of the used execution pattern, the of muscular activity curve and the corresponding electromyography. In the schemes, the height of the line representing the electromyographic profile does not have any numerical correspondence with the action potential levels.

Figure 5 shows the electric activity levels for PMC and DA, in different modalities of military press exercises in percentage of individuals.

Table 1 shows the statistical comparison among the different execution modalities of military press exercises.

4 Discussion

The results obtained from this study as for the PMC and DA muscles participation along the sequence of abduction and adduction, during the military press exercises, confirmed the initial expectation and corroborated with those already proposed by some authors.

For the clavicular portion of the pectoralis major muscle, we observed high inactive level. In the sitting forward modality, the inactivity level was lower than in the other modalities, however, in all modalities, the PMC activity was concentrated in the weak potential. Such data corroborate with the ones by Rasch and Burke (1977), who attribute to that muscle the role of an accessory in abduction movement.

For the anterior portion of the deltoid muscle, we observed high level of very strong action potential in all modalities, confirming its function of primary motor in abduction attributed by Wirned (1986), Campos (1987) and Campos, Vitti and Freitas (1992).

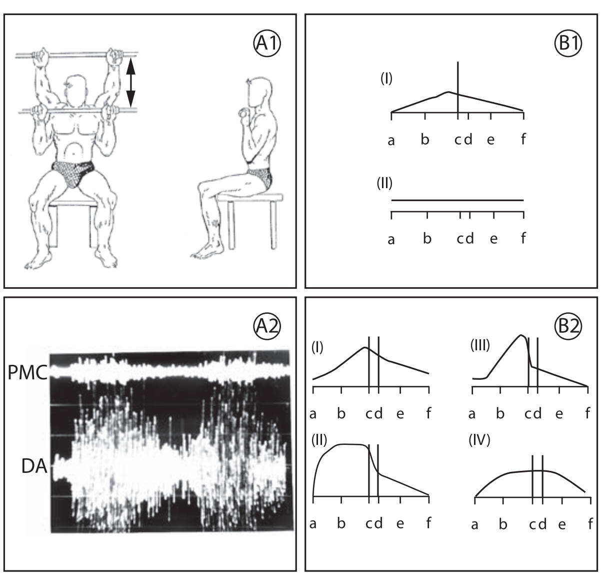

Figure 3. Movement of sitting military press – forward – middle grip. A1) Representation of the movement executed. A2) Electromyograph of the pectoralis major – clavicular portion (PMC) and deltoid - anterior portion (DA). Activity levels: PMC (+) and DA (4+). Calibration (C) = 200 µV; velocity (v) = 370 ms/div. Schematic representation of electromyographic profiles: B1) Observed for PMC: I) 64.7% of active individuals; II) 35.3% of activity individuals. B2) Observed for DA: I) 37.5% of active individuals; II) 33.3% of active individuals; III) 25.0% of active individuals and IV) 4.2% of active individuals; a = start position (hands upon thigh); b = middle point of bar elevation; c = maximum bar elevation; d = bar descent beginning; e = middle point of bar descent; f = return to start position.

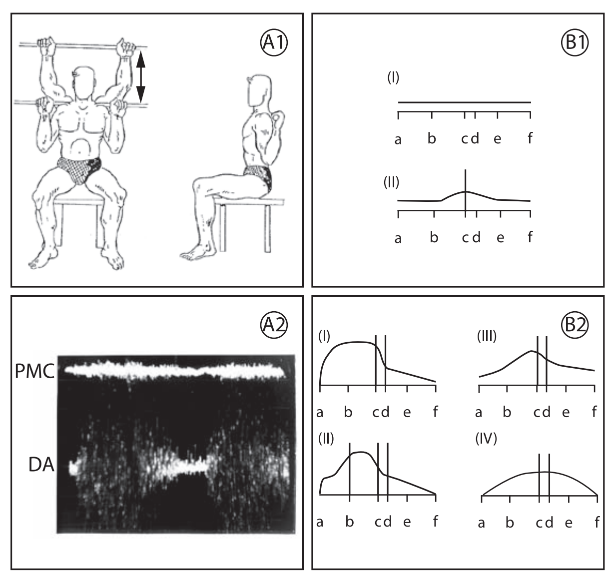

Figure 4. Movement of sitting military press – behind neck – middle grip. A1) Representation of the movement executed. A2) Electromyograph of the pectoralis major – clavicular portion (PMC) and deltoid – anterior portion (DA). Activity levels: PMC (+) and DA (4+). Calibration (C) = 200 µV; velocity (v) = 370 ms/div. Schematic representation of electromyographic profiles: B1) Observed for PMC: I) 53.8% of active individuals and II) 46.1% of active individuals. B2) Observed for DA: I) 37.5% of active individuals and II) 29.2% of active individuals; III) 20.8% of active individuals and IV) 12.5% of active individuals; a = start position (hands upon thigh); b = middle point of bar elevation; c = maximum bar elevation; d = bar descent beginning; e = middle point of bar descent; f = return to start position.

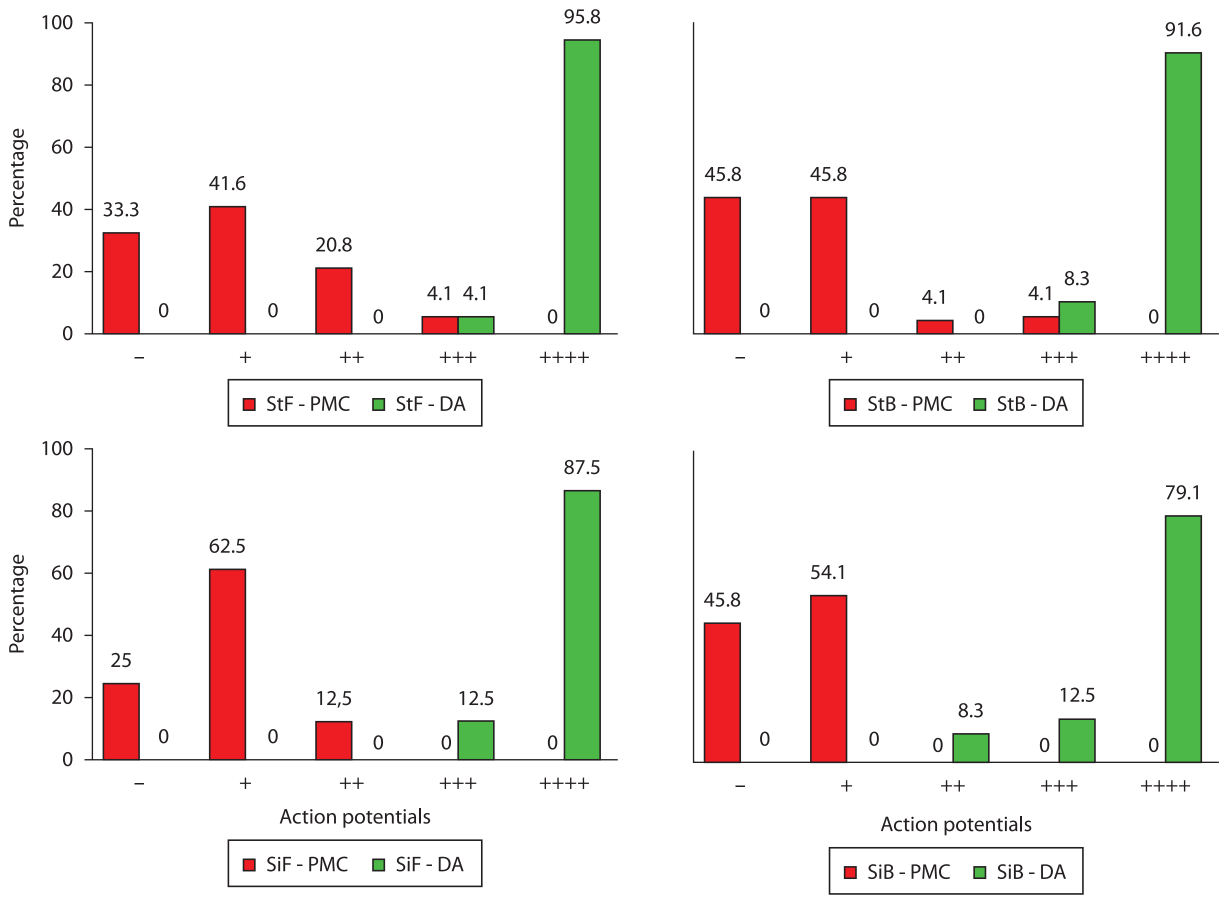

Figure 5. Incidence of different intensities recorded in the pectoralis major – clavicular portion (PMC) and deltoid – anterior portion (DA) in standing forward military press exercises (StF) and behind neck (StB); sitting forward (SiF) and behind neck (SiB) with open grip.

Table 1. Comparison among the exercises execution modalities with open grip by the pectoralis major – clavicular portion (PMC) and deltoid – anterior portion (DA).

Exercises	p-value	
	PMC	DA
StF × StB	0.554	0.059
StF × SiF	0.176	0.237
StF × SiB	0.799	0.013
StB × SiF	0.225	0.625
StB × SiB	0.686	0.272
SiF × SiB	0.142	0.063

The PMC activity profile in the beginning of the second phase, in most modalities, was reduced to low levels and maintained, meaning that this muscle has the role of accessory sustentation, shoulder stabilizer, what is in accordance with Jonsson and Jonsson (1975), who state that the clavicular portion of the pectoralis major muscle is responsible for the shoulder stabilization in complex movements of the steering wheel and Jobe, Moynes, Tibone et al. (1984), in pitching. On the other hand, Bearn (1961) did not notice any activity of the deltoid and pectoralis major for the posture maintenance without loads, while Scheving and Pauly (1959); Wright (1962); Rasch and Burke (1977) and De Luca and Forrest (1973) cite the deltoid muscle as an important shoulder stabilizer.

The DA activity profile shows a gradating fall of the action potential levels during the bar coming to the initial position, suggesting an active participation to control the member return to the initial position.

Peat and Grahame (1977) found activity for the three portions of the deltoid during the shoulder adduction, however, with lower levels than those observed during abduction, which, according to the authors, was consistent with the eccentric muscular work.

For Scheving and Pauly (1959) and Rasch and Burke (1977), only the sternocostal portion of the pectoralis major acts in adduction.

The participation simultaneity of PMC and DA observed in the electromyographic profile makes us consider them an agonist pair for the shoulder joint movement.

For DA, it was not observed any significant difference among the execution modalities. Significant difference as for the requirement capacity of PMC was observed only among the modalities sitting forward and sitting press behind neck, with superiority of the first over the second.

This way and considering the individual´s comfort and the possibility of lombar lordosis compensation during the execution, we suggest as preferential the sitting forward military press exercise.

It was observed in our results the importance of all military press exercises modalities for DA hypertrophy, what validates the indications found by O'Shea (1976), Machado (1980) and Lambert (1987). On the other hand, for the PMC hypertrophy work, two execution forms, standing and sitting, are mentioned by O'Shea (1976), what was not confirmed in our studies.

Acknowledgments: We would to thank Mr. Roberto Carvalho Prado and Benedicto Vinicius Aloise for the works they have done.

References

BASMAJIAN, JV. *Muscle alive*: their function revealed by electromyography. 4th ed. Baltimore: Williams & Wilkins, 1978. 561 p.

BASMAJIAN, JV. and DE LUCA, CJ. *Muscle alive*: their function revealed by electromyography. Baltimore: Williams & Wilkins, 1985.

BEARN, JG. Function of certain shoulder muscles in posture and in Rolding Weights. *Annals of Physical Medicine*, 1961, vol. 6, p. 100-104. PMid:13688245.

BÜLL, ML., FREITAS, V., VITTI, M. and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in military press exercises with open grip. *Electromyography and Clinical Neurophysiology*, 2001a, vol. 41, p. 179-184. PMid:11402510.

BÜLL, ML., FREITAS, V., VITTI, M. and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in military press exercises middle grip. *Electromyography and Clinical Neurophysiology*, 2001b, vol. 41, p. 263-268. PMid:11572186.

BÜLL, ML., FREITAS, V., VITTI, M., and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in military press exercises with open and middle grip. *Electromyography and Clinical Neurophysiology*, 2001c, vol. 41, p. 203-207. PMid:11441637.

BÜLL, ML., FREITAS, V., VITTI, M. and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in rowing exercises with middle grip. *Electromyography and Clinical Neurophysiology*, 2002a, vol. 42, p. 403-411.

BÜLL, ML., FREITAS, V., VITTI, M. and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in rowing exercises with closed grip. *Electromyography and Clinical Neurophysiology*, 2002b, vol. 42, p. 451-457.

BÜLL, ML., FREITAS, V., VITTI, M. and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in frontal-lateral cross, dumbbells exercises. *Journal of Neurophysiology*, 2002c, vol. 42, p. 31-38. PMid:11938598.

BÜLL, ML., FREITAS, V., VITTI, M. and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in the rowing and frontal-lateral cross, dumbbells exercises. *Electromyography and Clinical Neurophysiology*, 2002d, vol. 42, p. 79-84.

BÜLL, ML., VITTI, M., FREITAS, V. and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in pull-over exercises. *Brazilian Journal of Morphological Sciences*, 2002e, vol. 18(1), p. 69-73.

BÜLL, ML., VITTI, M., FREITAS, V., ROSA and GJM. Electromyographic validation of the trapezius and serratus anterior muscles in supine and frontal elevation exercises. *Brazilian Journal of Morphological Sciences*, 2002f, vol. 18(1), p. 75-79.

BÜLL, ML., FREITAS, V., VITTI, M., and ROSA, GJM. Electromyographic validation of the trapezius and serratus anterior muscles in rowing exercises with middle and closed grip. *Electromyography and Clinical Neurophysiology*, 2003, vol. 43, p. 4-8.

CAMPOS, GER. *Estudo eletromiográfico dos músculos trapézio e deltóide em movimentos livres do ombro e braço*. Piracicaba: Faculdade de Odontologia, Universidade Estadual de Campinas, 1987. 75 p. [Dissertação de Mestrado em Biologia e Patologia Buco-Dental].

CAMPOS, GER., VITTI, M. and FREITAS, V. Estudo eletromiográfico dos músculos trapézio e deltóide em movimentos do braço. *Revista Brasileira de Ciências Morfológicas*, 1992, vol. 9, p. 9-14.

DE LUCA, CJ. and FORREST, WJ. Force analysis of individual muscles acting simultaneously on the shoulder joint during isometric abduction. *Journal of Biomechanics*, 1973, vol. 6, n. 4, p. 385-386. http://dx.doi.org/10.1016/0021-9290(73)90098-5

DIAS, GAR. *Exercícios de força para músculos do braço utilizando o peso corporal*: uma análise eletromiográfica. Botucatu: Instituto de Biociências, Universidade Estadual Paulista, 2000. [Dissertação de Mestrado em Ciências Biológicas - Anatomia].

DIAS, GAR., GUAZZELLI, JF., RODRIGUES, JA., GONÇALVES, M. and BÜLL, ML. Electromyographic analysis of the arms muscles in "front support" exercises. *Electromyography and Clinical Neurophysiology*, 2003, vol. 43, p. 465-470.

FERREIRA, MI., BÜLL, ML. and VITTI, M. Electromyographic validation of basic exercises for physical conditioning programmes. I. Analysis of the deltoid muscle (anterior portion) and pectoralis major muscle (clavicular portion) in rowing exercises with middle grip. *Electromyography and Clinical Neurophysiology*, 1995, vol. 35, p. 239-245. PMid:7555929.

FERREIRA, MI., BÜLL, ML. and VITTI, M. Electromyographic validation of basic exercises for physical conditioning programmes. II. Analysis of the deltoid muscle (anterior portion) and pectoralis major muscle (clavicular portion) in rowing exercises with closed grip. *Electromyography and Clinical Neurophysiology*, 1996a, vol. 36, p. 81-85. PMid:8925784.

FERREIRA, MI., BÜLL, ML. and VITTI M. Electromyographic validation of basic exercises for physical conditioning programmes. III. Influence of the grip in the capacity of the rowing exercises in determining action potential levels for the deltoid (anterior portion) and the pectoralis major muscle (clavicular portion). *Electromyography and Clinical Neurophysiology,* 1996b, vol. 36, p. 86-90. PMid:8925785.

FERREIRA, MI., BÜLL, ML. and VITTI, M. Electromyographic validation of basic exercises for physical conditioning programmes. IV. Analysis of the deltoid muscle (anterior portion) and pectoralis major muscle (clavicular portion) in frontal-lateral cross, dumbbells exercises. *Electromyography and Clinical Neurophysiology*, 2003a, vol. 43, p. 67-74. PMid:12661129.

FERREIRA, MI., BÜLL, ML. and VITTI, M. Electromyographic validation of basic exercises for physical conditioning programmes. V. The comparison of the response in the deltoid muscle (anterior portion) and the pectoralis major muscle (clavicular portion) determined by the frontal-lateral cross, dumbbells and the rowing exercises. *Electromyography and Clinical Neurophysiology*, 2003b, vol. 43, p. 75-79. PMid:12661130.

FERREIRA, MI., BÜLL, ML. and VITTI, M. Participation of the deltoid (anterior portion) and pectoralis major (clavicular portion) muscles in different modalities of supine and 45 frontal elevation exercises with different grips. *Electromyography and Clinical Neurophysiology*, 2003c, vol. 43, p. 131-140. PMid:12712801.

JOBE, FW., MOYNES, DR., TIBONE, JE., PERRY, J. An EMG analysis of the shoulder in pitching. A second report. *American Journal of Sports Medicine* 1984, vol. 12, p. 218-220. PMid:6742305. http://dx.doi.org/10.1177/036354658401200310

JONSSON, S. and JONSSON, B. Function of the muscles of the upper limb in car driving. *Ergonomics*, 1975, vol. 18, p. 375-388. PMid:1193083. http://dx.doi.org/10.1080/00140137508931471

KAWANISHI, M., YAHAGI, S., SHIMURA, K. and KASAI, T. Dependence of deltoid muscle ativity upon initial angles of shoulder abduction prior to flexion. *Perceptual & Motor Skills*, 1999, vol. 88, p. 879-891. PMid:10407894.

LAMBERT, G. *Musculação*: guia de treinamento. São Paulo: Manole, 1987. 162 p.

LEVIN, J. *Estatística aplicada às ciências humanas.* 2th ed. Scranton: Harper & Row do Brasil, 1987.

MACHADO, IL. *Modelagem do físico*: musculação ao alcance de todos. Rio de Janeiro: Tecnoprint, 1980. 174 p.

OKAMOTO, T., TAKAGI, K. and KUMAMOTO, M. Electromyographic study of elevation of the arm. *Research Journal of Physical Education*, 1967, vol. 2, p. 127-136.

O'SHEA, JP. *Scientific principles and methods of strength fitness.* 2th ed. Massachussets: Addison - Wesley, 1976. 191 p.

PEAT, M. and GRAHAME, RE. Electromyographic analysis of soft tissue lesions affecting shoulder function. *American Journal of Physical Medicine*, 1977, vol. 56, p. 223-240.

PEDRO, MIF. *Validação eletromiográfica de exercícios básicos aos programas de condicionamento físico propostos para o desenvolvimento dos músculos deltóide (porção anterior) e peitoral maior (porção clavicular)*. Botucatu: Instituto de Biociências, Universidade Estadual Paulista, 1992. [Tese de Mestrado em Ciências Biológicas - Anatomia].

RASCH, PJ. and BURKE, RK. *Cinesiologia e Anatomia Aplicada*: A Ciência do Movimento Humano. 5th ed. Guanabara Koogan: Rio de Janeiro, 1977.

RODRIGUES, A. *A pesquisa experimental em psicologia e educação.* Rio de Janeiro: Vozes, 1975.

RODRIGUES, JA. *Validação eletromiográfica do exercício de voador proposto para o condicionamento dos músculos peitoral maior (porções esternal e clavicular) e deltóide (porção anterior)* Botucatu: Instituto de Biociências, Universidade Estadual Paulista, 2001. [Tese de Mestrado em Ciências Biológicas - Anatomia].

RODRIGUES, JA., BÜLL, ML., DIAS, GAR., GONÇALVES, M. and GUAZZELLI, JF. Electromyographic analysis of the pectoralis major and deltoideus anterior muscles in horizontal "flyer" exercises with loads. *Electromyography and Clinical Neurophysiology*, 2003, vol. 43, p. 413-419.

SCHEVING, MG. and PAULY, JE. An electromyographic study of some muscle acting on the upper extremity of man. *The Anatomical Record*, 1959, vol. 135, p. 239-245. http://dx.doi.org/10.1002/ar.1091350402

SIGHOLM, G., HERDERTS, P., ALMNSTROM, C. and KADEFORS, R. Electromyographic analysis of shoulder muscle load. *Journal of Orthopaedic Research*, 1984, vol. 1, p. 379-386. PMid:6491787. http://dx.doi.org/10.1002/jor.1100010406

SOUSA, OM., BERZIN, F. and BERERDI, AC. Electromyographic study of the pectoralis maior and latissimus dorsi muscle during medial rotation of the arm. *Electromyography*, 1969, vol. 4, p. 407-416.

WIRNED, R. *Atlas de anatomia do movimento.* São Paulo: Manole, 1986.

WRIGHT, WG. *Muscles functi*on. New York: Hafner, 1962.

Received January 12, 2011
Accepted November 25, 2011