Journal of Strength and Conditioning Research, 2002, 16(4), 539–546

A Comparative Electromyographical Investigation of Muscle Utilization Patterns Using Various Hand Positions During the Lat Pull-down

JOSEPH F. SIGNORILE, ATTILA J. ZINK, AND STEVEN P. SZWED

Human Performance Laboratory, Department of Exercise and Sport Sciences, University of Miami, Coral Gables, Florida 33124.

ABSTRACT

This study aimed at investigating the effects of different hand positions on the electromyographic (EMG) activity of shoulder muscles during the performance of the lat pull-down exercise. Ten healthy men performed 3 repetitions of the lat pull-down exercise using their experimentally determined 10RM (repetition maximum) weight. Four different common variations of the lat pull-down were used: close grip (CG), supinated grip (SG), wide grip anterior (WGA), and wide grip posterior (WGP). Normalized root mean square of the EMG (NrmsEMG) activity for the right posterior deltoid (PD), latissimus dorsi (LD), pectoralis major (PM), teres major (TM), and long head of the triceps (TLH) were recorded using surface electrodes and normalized using maximum voluntary contractions. Repeated measures analysis of variance for each muscle detected statistical differences ($p < 0.05$) in myoelectric activity among hand positions during both the concentric and eccentric phases of the exercise. During the concentric phase, NrmsEMG results for the LD included WGA > WGP, SG, CG. For the TLH: WGA > WGP, SG, CG and WGP > CG, SG. For the PD: CG, WGA, SG > WGP. For the PM: CG, WGA, SG > WGP. During the eccentric phase, the LD produced the following patterns: WGA > WGP, SG, CG and WGP > CG. The TLH pattern showed WGA > SG and CG. For the PD: CG > WGA, WGP. The results indicate that changes in handgrip position affect the activities of specific muscles during the lat pull-down movement. Also, performance of the lat pull-down exercise using the WGA hand position produces greater muscle activity in the LD than any other hand position during both the concentric or eccentric phases of the movement.

Key Words: latissimus dorsi, resistance training, muscular activity

Reference Data: Signorile, J.F., A.J. Zink, and S.P. Szwed. A comparative electromyographical investigation of muscle utilization patterns using various hand positions during the lat pull-down. *J. Strength Cond. Res. 16(4):539–546. 2002.*

Introduction

The act of pulling the arms down to the sides from an overhead position (or raising the body when the arms are secured overhead, as in pull-ups) does not play a major role in most sports. But to swimmers swimming freestyle (crawl), breaststroke, and butterfly; gymnasts performing on the rings, horizontal, parallel, and uneven bars; basketball players pulling down a rebound; and wrestlers executing specific holds and takedowns, this arm motion is essential (21). These sports contain movements, which rely heavily on the muscles that produce adduction of the shoulder joint. The major muscles involved in this movement include the latissimus dorsi (LD), teres major (TM), and pectoralis major (PM) (6, 8, 13, 16, 18). In addition to their importance for specific sports movements, the development of these muscles is also important to promote functional balance about the shoulder joint and the symmetry that is important to both bodybuilders and recreational lifters (3, 4, 7, 10, 15).

Many exercises can be prescribed for the strength development of the shoulder adductor muscles (1, 3, 4, 7, 10, 15). One such exercise is the lat pull-down (9–11, 14, 19–21). Several variations of this exercise are performed in weight rooms. These variations normally involve changes in hand position and range of motion (ROM) (1, 5, 12, 19–21). Many articles in both professional journals and the popular literature have offered differing opinions concerning the best hand and bar positions for targeting the LD during the performance of the lat pull-down exercise (1, 5, 12, 19–21). The differences in opinion among fitness professionals were further illustrated by an on-line poll held by the National Strength and Conditioning Association. When asked whether the front or back lat pull-down was superior at developing the LD, 150 members favored the back pull-down position, whereas 903 members voted for the front pull-down. Few controlled studies that have examined the lat pull-down exist (19), and no study has examined the effect of hand position on specific muscle recruitment patterns during the performance of the exercise. Therefore, the purpose of this study was to investigate the effects of 4 commonly used hand positions on the activity of selected shoulder muscles during the performance of the lat pull-down exercise.

Methods

Experimental Approach to the Problem

Articles in professional journals and fitness periodicals have argued the superiority of various handgrip positions for targeting the LD during the lat pull-down exercise (1, 5, 12, 19–21). We used 4 of the most commonly used handgrip positions to examine which handgrip elicited the highest level of electrical activity in the LD and 4 other accessory muscles. Electromyographical signals (EMG) were collected from each muscle during performance of the lat pull-down under each condition using the same cadence. According to convention, the root mean square of the EMG signal (rmsEMG) was used to quantify the average level of electrical activity produced during each condition (2). The signals were normalized to reduce the effect of variations in signal amplitude among muscles and subjects. These variations may result from differences in surface preparation, temperature, and other factors that affect the electrical impedance of the surface electrodes (2). Comparisons were made among handgrip positions within each muscle. All tests were performed on the same day, and the orders of both the exercise testing and the isometric contractions used for normalization were randomized to reduce the effect of any order effect. These procedures were designed to address the effectiveness of each exercise at targeting specific muscles because some controversy regarding their relative efficacy and safety still exists.

Subjects

Ten healthy men between the ages of 18 and 50 (27 ± 2.4 years) with a minimum of 1 year of weightlifting experience (5.9 ± 4.6 year) volunteered as subjects. Each subject completed a health history and exercise questionnaire and was screened for a history of back injury, chronic back pain, and musculoskeletal or neurological impairments. The testing procedures were approved by the University of Miami Subcommittee for the Protection of Human Subjects. All subjects completed a university-approved informed consent form before participation.

Equipment

Subjects performed the lat pull-down exercise on a standard lat pull-down cable system (Spartan, Minneapolis, MN), whereas EMG was recorded using a pair of disposable Ag/AgCl pregelled disk surface electrodes (Eaton Electrode, Manchester, MI) placed on the right posterior deltoid (PD), LD, PM, TM, and long head of the triceps (TLH). Electrode pairs were positioned immediately distal to the motor point, 2 cm apart, and parallel to the underlying muscle fibers, with the reference electrode placed upon the clavicle. Motor points were located using a low-voltage stimulator delivering progressively lower intensity 1-millisecond pulses at a rate of 0.5 Hz (17).

The skin surface at each site was shaved, rubbed with light abrasive paper, and cleaned with alcohol to remove dead surface tissue and oils that might reduce the fidelity of the signal.

Raw EMG signals were recorded using a wireless EMG telemetry system (Noraxon USA, Scottsdale, AZ) with an input impedance of 2 MΩ and a common mode rejection ratio (CMRR) of 100 dB. The gain was set at 2,000, with band pass filtering between of 1 and 500 Hz. The signals were sampled at a speed of 1,024 Hz, digitized using a 16-bit A/D converter (DataPac, Laguna Beach, CA) and stored using a microcomputer. Recorded signals were examined with the use of Lab View Software (DataPac, Laguna Hills, CA), and the root mean square of the rmsEMG was used to evaluate the amplitude of the signal as a measure of average muscle activity (2).

Procedure

Approximately 1 week before testing, subjects were pretested and height, weight, and limb length measurements were recorded. A tape measure was used to measure limb lengths as follows: hamate to the olecranon process for the forearm, olecranon process to acromian process for the upper arm, and acromian process to C7 for the biacromial diameter. A 10RM (repetition maximum) was determined for each subject during the lat pull-down performances using each of the 4 different common variations of the lat pull-down: close grip (CG), supinated grip (SG), wide grip anterior (WGA), and wide grip posterior (WGP). These positions are illustrated in Figure 1a–d. The CG pull-down was performed with a V-Bar and, therefore, grip width was fixed. The SG, WGA, and WGP were performed using a standard lat pull-down bar with the handgrip positions determined as follows: The SG was performed with a supinated handgrip, and the biacromial diameter was used to determine the distance between hands. Both WGA and WGP were performed with a pronated handgrip, and the distance between the hands was equal to the distance from the outside of a closed fist to the seventh cervical vertebra (C7). This was done with the arm abducted straight out to the side at shoulder level (similar to snatch grip width determination techniques). All anterior lifts (CG, SG, and WGA) were conducted from full arm extension to bar contact with the chest, and the posterior lift (WGP) was performed from full arm extension to bar contact with C7. All subjects were instructed to keep their

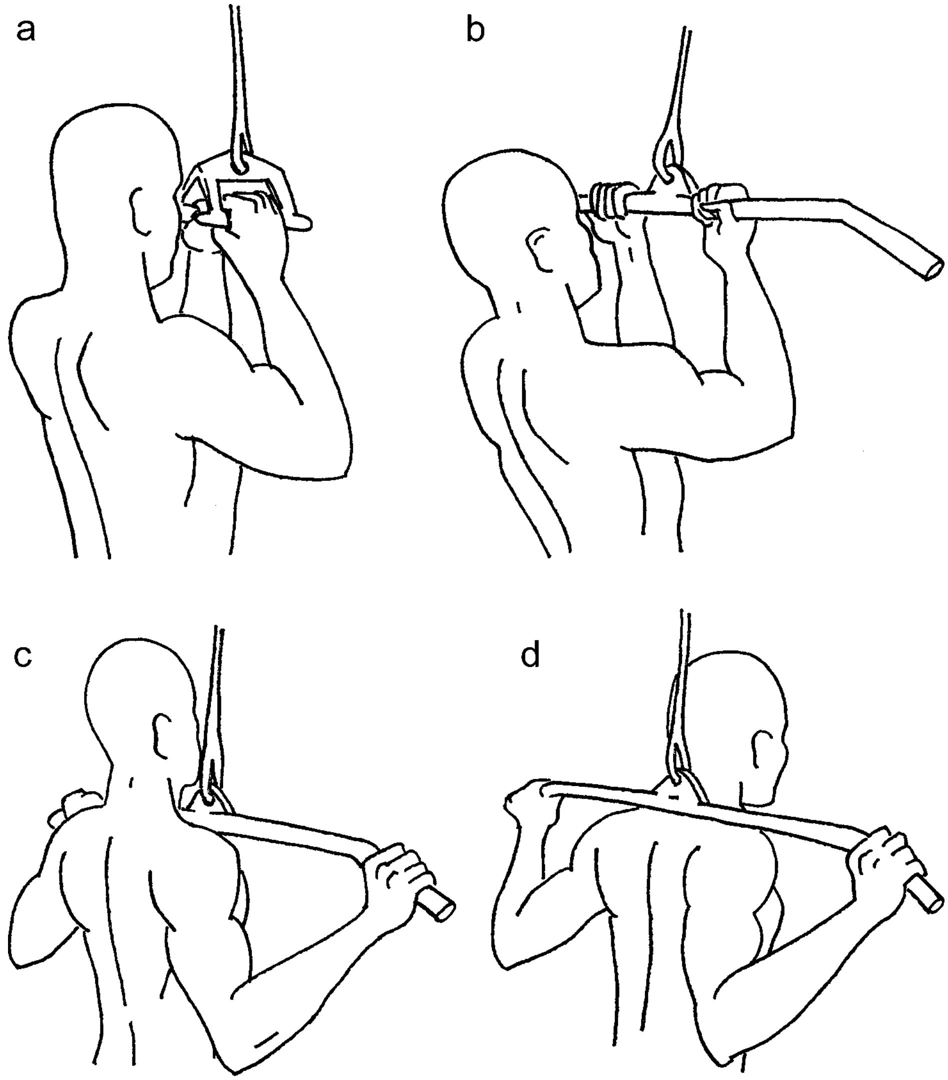

Figure 1. Hand positions examined during the lat pull-down: (a) close grip, (b) supinated grip, (c) wide grip anterior, and (d) wide grip posterior.

scapulae retracted during the posterior lift to avoid excessive cervical flexion. They were also directed to maintain normal postural lordosis of the lumbar region during the anterior lifts.

On the testing day, maximum voluntary contractions (MVCs) of the muscles to be tested were determined by having the subject perform bilateral isometric contractions using the following procedures: PD, pulling backward against the cable using a seated row position with pronated grip, arms parallel to ground, and shoulders horizontally flexed to approximately 10°; LD, pulling downward using seated row position with SG, elbows held at approximately 90° and arms parallel to ground; PM, pushing medially while seated in a pec-fly machine (Nautilus, Independence, VA) with shoulder abducted to 90° and elbows flexed to 90°; TM, horizontally adducting the shoulder against manual resistance; TLH, performing a standing triceps push-down with a pronated grip and elbows bent at 90°. Each contraction was held constant for 6 seconds, and EMG data were collected for the last 3 seconds. The exercise order was randomly assigned, and subjects were given a minimum of 2 minutes rest between lifts to minimize the effects of fatigue.

Before testing each lift, the full ROM for that lift was determined, and a magnetic marker switch was placed on the structural supports of the lat pull-down machine at the top and bottom point of each subjects' range. A magnet was placed at the top of the weight stack, and an electric buzzer sounded as the weight stack passed the magnetic switches marking the bottom and top of each subject's ROM. The buzzer also produced a voltage spike recorded during the EMG collection to allow the separation of the lift into its concentric and eccentric phases. The subjects were instructed not to reverse the direction of the lift until the buzzer sounded. Subjects performed 3 repetitions of each condition in a controlled manner throughout their respective ROMs, with both the concentric and eccentric portions of the lift being executed for 2-second durations. Lift order was randomly assigned, and subjects were given 2 minutes rest between lifts to minimize the effects of fatigue.

Statistical Analyses

A single-factor analysis of variance (ANOVA) was used to detect significant differences ($p \leq 0.05$) between average 10RM loads used for each hand position. The rmsEMG for each muscle at each hand position was normalized using the rmsEMG of the MVC collected on the testing day. Separate repeated measures ANOVAs were used to detect significant differences ($p \leq 0.05$) in mean normalized rmsEMG (NrmsEMG) values among the 4 hand positions during both the eccentric phase and concentric phases of the exercise. When appropriate, a Tukey's honestly significant difference post hoc test was used to determine which hand positions differed in mean NrmsEMG activity for each muscle. All statistical procedures were conducted using the SAS (SAS Institute Inc., Cary, NC) statistical package.

Results

The average 10RM load determined for each of the conditions was WGA = 141.0 ± 21.8 lb; WGP = 131.0 ± 19.1 lb; CG = 141.0 ± 16.6 lb; and SG = 139.0 19.7 lb. No statistically significant differences ($p < 0.05$) were detected among 10RM loads.

The mean NrmsEMG values for the LD, PM, PD, and TLH were statistically different ($p \leq 0.05$) during the concentric phases of the exercises. The graphical representations of the mean NrmsEMG data for each muscle tested are presented in Figure 2. Significantly greater NrmsEMG activity ($p \leq 0.05$) was detected for the LD during the WGA position compared with the WGP, SG, and CG positions, whereas no significant differences were detected among the other 3 positions (Figure 2a). For the PM, no significant differences in NrmsEMG were detected among the CG, SG, and WGA positions or among the SG, WGA, and WGP positions; however, significantly greater NrmsEMG activity was seen during the CG position compared with the WGP position (Figure 2b). The PD showed similar NrmsEMG activity during the CG, SG, and WGA positions. The WGP position produced significantly less electrical activity in the PM than any of the other 3 positions ($p \leq 0.05$) (Figure 2c). The TLH demonstrated statistically greater NrmsEMG activity ($p \leq 0.05$) for the WGA position compared with the WGP, CG, and SG positions (Figure 2d). The WGP position also produced greater NrmsEMG activity in the TLH than either the CG or SG positions (Figure 2d). No significant differences were detected between the CG and SG positions for the TLH. For the TM, no significant differences were found among any of the hand positions tested (Figure 2e).

Significant differences in the mean NrmsEMG values for the LD, PD, and TLH were detected also during the eccentric phase of the exercise ($p \leq 0.05$). The graphs of the mean NrmsEMG data for each muscle tested during the eccentric phase are presented in Figure 3. Statistically greater NrmsEMG activity ($p \leq 0.05$) was detected at the LD for the WGA position compared with the WGP, SG, and CG positions. The level of activity during the WGP position was not significantly greater than that produced during the SG position but was significantly greater than that produced during the CG position (Figure 3a). For the PD, no significant differences were detected between the CG and SG positions or among the SG, WGA, and WGP positions. The PD did demonstrate greater NrmsEMG activity ($p \leq 0.05$) during the CG position than during either the WGA or WGP hand positions (Figure 3c). For the TLH no significant differences were seen between the WGA and WGP positions or among the WGP, SG, and CG positions. The TLH did show greater NrmsEMG activity ($p < 0.05$) for the WGA position compared with the SG and CG positions (Figure 3d). No significant differences were detected in NrmsEMG among any of the hand positions for the PM or TM (Figure 3b,e).

Discussion

Before examining the EMG activity for the selected muscles tested in the study, it is appropriate to examine the inherent differences that existed in the lifts themselves. The loads used during the performance of the lat pull-down for the WGA, CG, and SG positions (141 lb, 141 lb, and 139 lb, respectively) were greater than those used during the WGP (131 lb). Although this difference was not statistically significant, there was a trend toward the use of lower loads during the execution of the lat pull-down with the WGP hand position than with other positions. These data suggest that the performance of the lat pull-down with the bar pulled anteriorly (to the chest) provides some mechanical advantage, allowing greater loads to be moved during these exercises than when the bar is pulled posteriorly (to the back of the neck). A 10RM load, rather than a standardized load, was used for each condition in an attempt to ensure that maximal effort was given during each treatment. Additionally, the load used during training would be relative to the capacity of the muscles to work in that position and would not have the same absolute value for each hand position. Although a standardized load may have been representative of a maximal effort in some positions, it may not have had magnitude high enough to provide a maximal effort in other positions and would not have simulated actual lifting conditions. On aver-

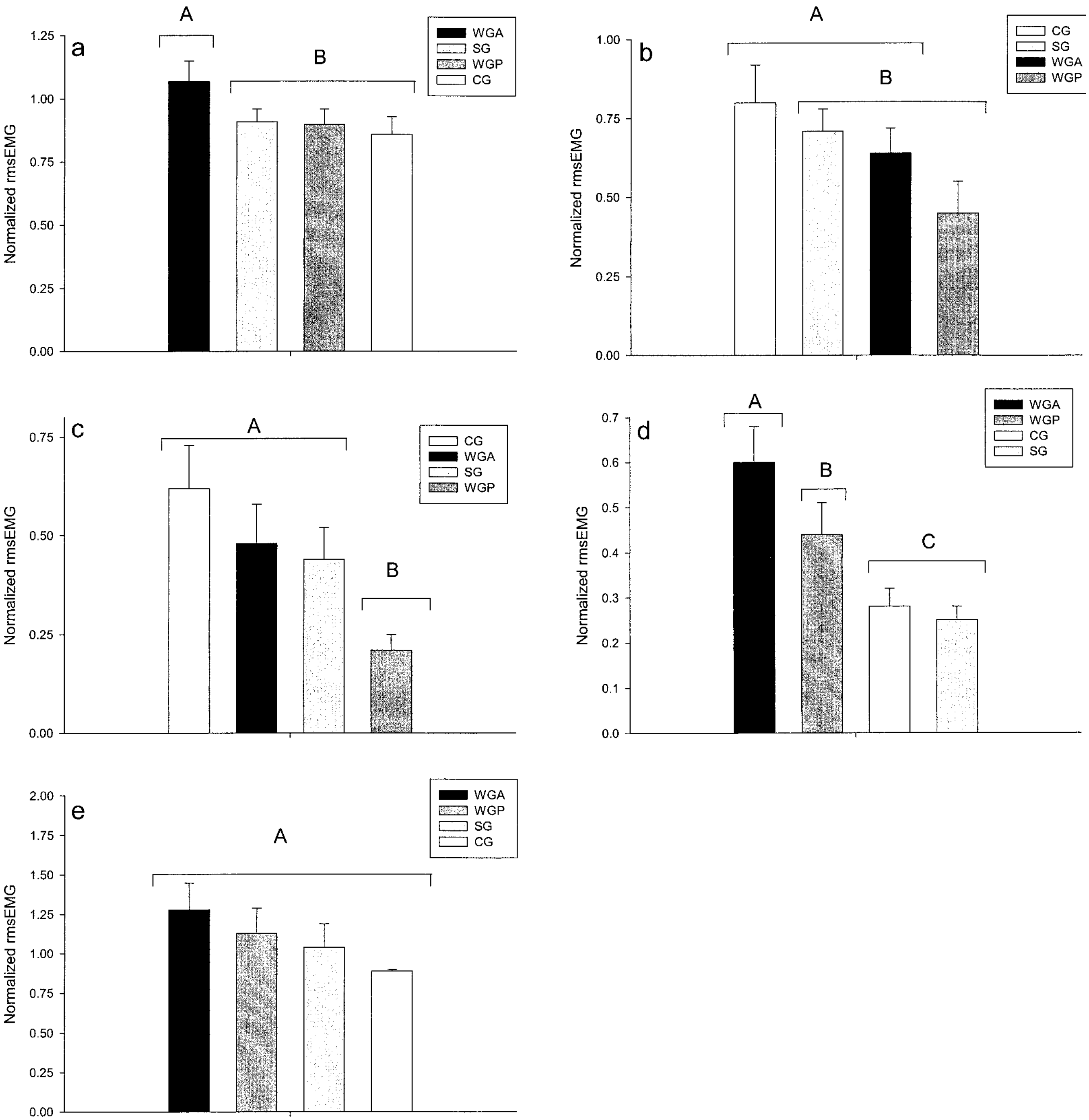

Figure 2. Mean NrmsEMG values for the latissimus dorsi (a), pectoralis major (b), posterior deltoid (c), long head of the triceps (d), and teres major (e) during the concentric phases of the lifts. Bars enclosed by brackets with different letters are significantly different ($p \leq 0.05$). WGA = wide grip anterior; WGP = wide grip posterior; SG = supinated grip; and CG = close grip.

age a 10-lb lighter load was used during the WGP handgrip position than during the 3 other handgrip positions. If these differences exist among the lifts as practiced under normal working conditions, the differences in rmsEMG activities for the specific muscles across lifting conditions can now be discussed.

Although no direct kinematic measurements were made during this study, generalized statements concerning the effect of various handgrips on the position of the upper arm at the glenohumeral joint can be made. These positions can provide some explanation for the recruitment patterns seen by the muscles crossing the shoulder joint and attaching to the humerus.

Data from the LD collected using each of the hand positions during both the eccentric and concentric phases of each lift indicate that the WGA position pro-

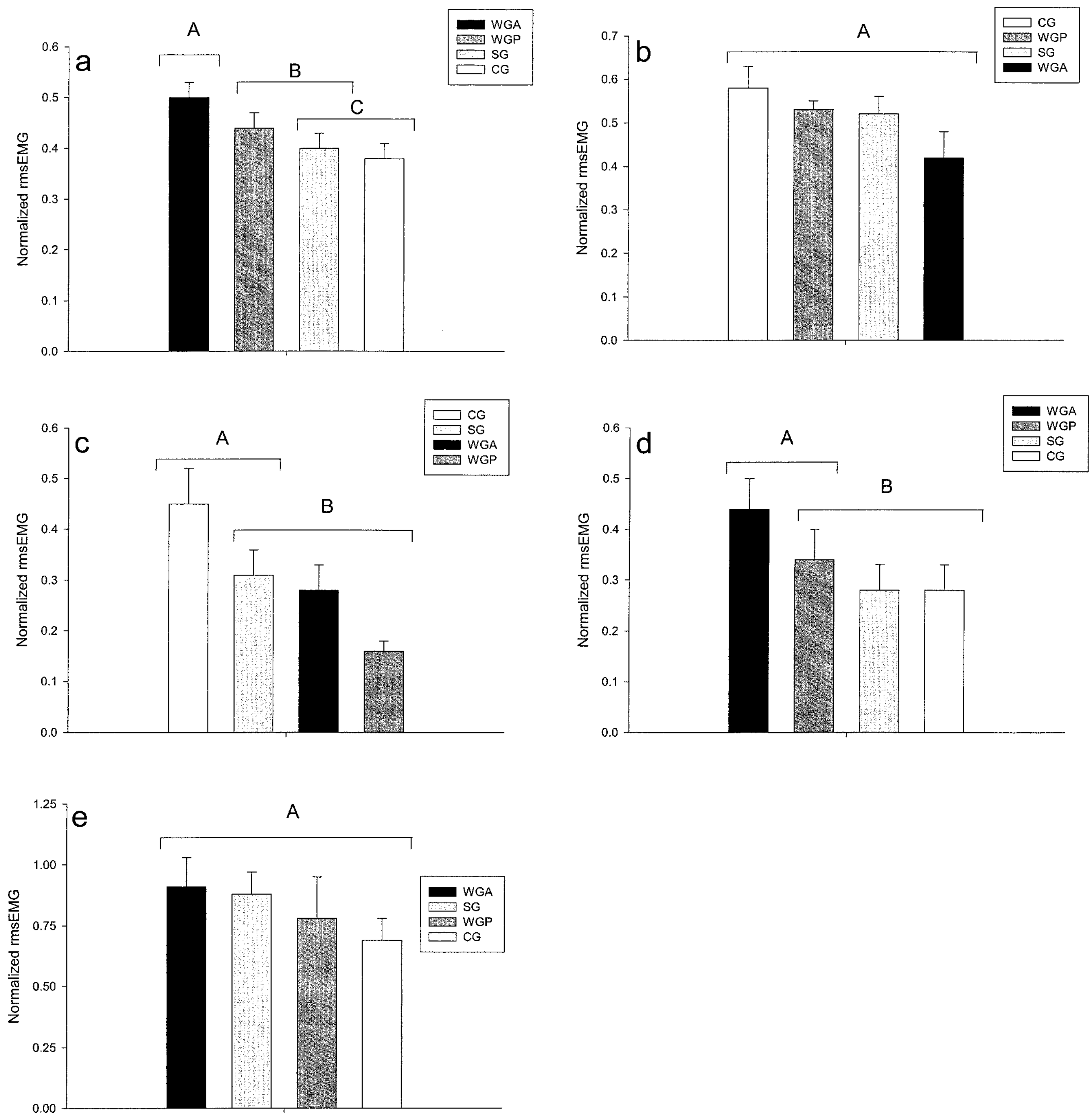

Figure 3. Mean NrmsEMG values for the latissimus dorsi (a), pectoralis major (b), posterior deltoid (c), long head of the triceps (d) and teres major, and (e) during the eccentric phases of the lifts. Bars enclosed by brackets with different letters are significantly different ($p \leq 0.05$). WGA = wide grip anterior; WGP = wide grip posterior; SG = supinated grip; and CG = close grip.

duced greater electrical activity than any other position tested. During the concentric phase of the lift, LD NrmsEMG was similar for all remaining hand positions, whereas during the eccentric portion of the lifts, the WGP and SG conditions produced similar results and the SG and CG conditions were also similar. But the WGP position did produce significantly higher NrmsEMG than the CG position. When comparing the WGA with the SG and CG, the WGA requires greater abduction and horizontal abduction than the other 2 conditions. The functions of the LD include adduction of the arm from an abducted position, horizontal abduction, and extension from a flexed position. Given these functions, it appears that the starting position for the WGA, which places the arm in a more horizontally abducted position throughout the exercise, increases the reliance on the LD compared with the SG and CG positions. Evidently, the WGP position, although it demands an even greater degree of horizontal abduction, does not require the individual to produce the same degree of extension that the WGA does because of its more linear movement track along the sagittal plane behind the neck. In the WGP position, there is also a greater level of shoulder girdle depression. This could increase the emphasis on the lower trapezius and rhomboid groups at the cost of LD activity. The results of this study agree with those reported by Wills et al. (19), which indicated that a wide grip, whether anterior or posterior, elicited a greater level of electrical activity in the LD than a CG. Those researchers also indicated that a wide anterior grip produced greater activity in the lateral portion of the LD than a wide posterior grip. Although the current study did show that the WGA position produced greater levels of activity than the WGP, it is not possible to make an exact comparison between the results because of the differences in electrode placement and experimental design between the 2 studies.

The NrmsEMG activity pattern for the TM, although it produced no significant differences among hand positions, did follow a pattern similar to that of the LD. Interestingly, the eccentric data for the TM reflect the concentric data for the LD and the eccentric TM data reflect those produced by the LD during the concentric phase of the lift. These similarities are expected because of the TM role as the muscle that assists the LD in adducting and extending the humerus. Its smaller size and more horizontal angle of pull may account, to some degree, for the more subtle changes seen among the hand positions for the TM compared with the LD. In addition, Kraemer and Schmotzer (9) noted that the maximal activity of the TM does not occur until 90° of humeral elevation, indicating that it would produce lower NrmsEMG activity than the LD throughout a large portion of the lift. Finally, its origin on the inferior third of the lateral border of the scapula reduces its level of activity when the scapula is not stabilized or when it is downwardly rotated.

The patterns seen for the TLH during the eccentric and concentric portions of the lifts are indicative of its function as an extensor of the humerus and its site of insertion at the infraglenoid tubercle below the inferior lip of the glenoid fossa of the scapula and the olecranon process of the ulna. For both the eccentric and concentric phases of the lifts, the WGA produced the highest levels of electrical activity. For the concentric phase this difference was significantly greater than all other conditions, whereas for the eccentric phase the WGA produced greater activation than the CG and SG but not significantly higher activity than the WGP condition. The WGP condition produced activity similar to that of the SG and CG conditions during the eccentric phase and produced significantly greater activity than these conditions during the concentric phase. The increased activity produced by the 2 wide grip positions may be due to the greater tension placed on the muscle because of its increased length as the humerus is abducted. Because the scapula are drawn further back during the WGP compared with the WGA, this length is somewhat reduced and the extensor function of the TLH is emphasized less. This fact, in conjunction with the lower NrmsEMG values expected during eccentric vs. concentric contractions may have been responsible for the lack of significance seen between the WGA and WGP positions during the eccentric phase of the lift.

For the PM the pattern is similar for both the eccentric and concentric phases. The electrical activity was greatest for the CG condition, followed by the SG, WGA, and WGP conditions. As with the other muscles examined in this study, this pattern was dictated by the muscle's biomechanical function. The PM's major functions are horizontal adduction, internal rotation, adduction, and flexion of the humerus. As can be seen from the firing pattern, the hand position emphasizing greatest horizontal adduction and internal rotation, the CG condition, produced the highest level of electrical activity in this muscle. As the humerus became more abducted (SG $<$ WGA $<$ WGP) the level of activity of the PM was reduced.

The PD has as its major functions, the movement of the arm straight posteriorly, horizontal abduction, and external rotation and works with the anterior and middle fibers to move the arm laterally away from the body. The CG position, which uses both internal rotation and horizontal adduction, developed the highest level of electrical activity in this muscle for all hand positions tested. This higher level of activity could be because the muscle is at its greatest length, and therefore is under its greatest tension, under this condition.

Different handgrip positions change the degree of external/internal rotation abduction/adduction and horizontal abduction/adduction about the glenohumeral joint during the execution of the lat pull-down exercise. This, in turn, affects the relative contributions by the muscles involved in the performance of the pull-down movement. Handgrip positions placing the humerus into greater degrees of horizontal abduction (WGA, WGP) place greater emphasis on the LD and TM, whereas positions which increase the level of horizontal adduction (CG, SG) elicit more NrmsEMG from the PD and PM. Overall the WGA position proved superior at targeting the LD, during both the eccentric and concentric phases of the lifts, than any other hand position.

Practical Applications

Because the primary purpose of the lat pull-down exercise is the development of increased strength during shoulder adduction, it is of great importance to prescribe the handgrip position that elicits the most activity from the muscle primarily involved with this downward movement, namely the LD. The results of this study indicate that the wide grip hand position with the bar pulled anteriorly to the chest (WGA) recruits more motor units, and therefore requires more work from the LD than any of the other conditions tested. Therefore, this handgrip position should be used to provide a greatest amount stimulus and a greater development of the LD than other handgrip positions. This finding may be especially important because it brings into question the necessity to use the WGP position, which has been cited as a condition that increases the potential for injury to both the glenohumeral joint and cervical spine.

But if the purpose for the prescription of the pull-down exercise is to develop overall strength during shoulder adduction, or if the athletic movement being trained for involves adduction with the arm located more anteriorly, then the strength professional should also include handgrip positions which elicit more activity from the PM. The results of this study indicate that the CG hand position recruits more activity from the PM. Therefore, incorporation of pull-down movements with a CG can increase the overall development of strength for shoulder adduction (5, 10).

References

1. BAECHLE, T.R., R.W. EARLE, AND W.B. ALLERHEILIGEN. Strength training and spotting techniques. In: *Essentials of Strength Training and Conditioning.* T.R. Baechle, ed. Champaign, IL: Human Kinetics, 1994. pp. 345–400.
2. BASMAJIAN, J.V., AND C.J. DE LUCA. *Muscles Alive: Their Functions Revealed by Electromyography.* Baltimore: Williams & Wilkins, 1985.
3. BERGER, R.A. *Introduction to Weight Training.* Englewood Cliffs: Prentice Hall, 1984.
4. BOMPA, T.O., AND L.J. CORNACCHIA. *Serious Strength Training.* Champaign, IL: Human Kinetics, 1998.
5. CRATE, T. Analysis of the lat pulldown. *Strength Cond.* 19(3):26–29. 1997.
6. DANIELS, L., AND C. WORTHINGHAM. *Muscle Testing: Techniques of Manual Examination.* Philadelphia, PA: W.B. Saunders Company, 1972.
7. HATFIELD, F.C., AND M. KROTEE. *Personalized Weight Training for Fitness and Athletics: From Theory to Practice.* Dubuque: Kendall/Hunt Publishers, 1984.
8. KINZEY, S. The lat pulldown. *Strength Cond.* 20(2):76 1998.
9. KRAEMER, W.J., AND P.J. SCHMOTZER. Kinesiology corner: The lat pull. *Nat. Strength Cond. Assoc. J.* 2(5):42–43. 1980.
10. KRAEMER, W.J., AND S.J. FLECK. *Strength Training for Young Athletes.* Champaign, IL: Human Kinetics, 1993.
11. NEWTON, H. The lat pulldown. *Nat. Strength Cond. Assoc. J.* 20(2):76 1998.
12. PIERCE, K.C. Straight-arm lat pulldown and push-up on balance board. *Nat. Strength Cond. Assoc. J.* 20(6):52–53. 1998.
13. SEIG, K.W., AND S.P. ADAMS. *Illustrated Essentials of Musculoskeletal Anatomy.* Gainesville: Megabooks, 1985.
14. SIGNORILE, J.F., R. TUTEN, C. MOORE, AND V. KNIGHT. *Weight Training Everyone.* Winston-Salem, NC: Hunter Textbooks, 1993.
15. TESCH, P.A. *Muscle Meets Magnet.* Mansfield: BookMasters, 1993.
16. THOMPSON, C.W., AND R.T. FLOYD. *Manual of Structural Kinesiology.* St. Louis, MO: Mosby, 1994.
17. WALTHARD, K.M., AND M. TCHICALOFF. Motor points. In: *Electrodiagnosis and Electromyography.* S. Licht, ed. Baltiamore: Waverly Press, 1961. pp. 153–170.
18. WEINECK, J. *Functional Anatomy in Sport.* St. Louis, MO: Mosby Yearbook, 1990.
19. WILLS, R., J.F. SIGNORILE, A. PERRY, L. TREMBLAY, AND K. KWIATKOWSKI. Differences in EMG activity due to handgrip position during the lat pulldown. *Med. Sci. Sports Exerc.* 26(5): S20 1994.
20. YESSIS, M. Muscles: Narrow-grip pulldown. *Muscle Fitness* January:68–69. 1993.
21. YESSIS, M. Front lat pull-down. *Muscle Fitness* March:37–39. 1997.

Address correspondence to Dr. Joseph F. Signorile, Human Performance Laboratory, Department of Exercise and Sport Sciences, University of Miami, PO Box 248065, Coral Gables, Florida 33124.