Grip Width and Forearm Orientation Effects on Muscle Activity During the Lat Pull-Down

Stephen J. Lusk, Bruce D. Hale, and Daniel M. Russell

Department of Kinesiology, The Pennsylvania State University–Berks, Reading, Pennsylvania

Abstract

Lusk, SJ, Hale, BD, and Russell, DM. Grip width and forearm orientation effects on muscle activity during the lat pull-down. *J Strength Cond Res* 24(7): 1895–1900, 2010—Based on electromyographic (EMG) studies, an anterior (in front of the face) wide grip with a pronated forearm has been recommended as the optimal lat pull-down (LPD) variation for strengthening the latissimus dorsi (LD) (Signorile, JF, Zink, A, and Szwed, S. *J Strength Cond Res* 16: 539–546, 2002; Wills, R, Signorile, J, Perry, A, Tremblay, L, and Kwiatkowski, K. *Med Sci Sports Exerc* 26: S20, 1994). However, it is not clear whether this finding was because of grip width or forearm orientation. This study aimed to resolve this issue by comparing wide-pronated, wide-supinated, narrow-pronated, and narrow-supinated grips of an anterior LPD. Twelve healthy men performed the 4 grip variations using an experimentally determined load of 70% of 1 repetition maximum. Two trials of 5 repetitions were analyzed for each grip type. Participants maintained a cadence of 2-second concentric and 2-second eccentric phases. The grip widths were normalized for each individual by using a wide grip that corresponded to their carrying width and a narrow grip that matched their biacromial diameter. Surface EMG of the LD, middle trapezius (MT), and biceps brachii (BB) was recorded, and the root mean square of the EMG was normalized, using a maximum isometric voluntary contraction. Repeated-measures analysis of variance for each muscle revealed that a pronated grip elicited greater LD activity than a supinated grip ($p < 0.05$), but had no influence of grip type on the MT and BB muscles. Based on these findings, an anterior LPD with pronated grip is recommended for maximally activating the LD, irrespective of the grip width (carrying width or biacromial diameter).

Key Words EMG, latissimus dorsi, pronation, supination

Address correspondence to Dr. Bruce Hale, bdh1@psu.edu.

24(7)/1895–1900

Journal of Strength and Conditioning Research

Introduction

During a lat pull-down (LPD), the humerus is adducted under load via a pulley system. This exercise is commonly employed in an effort to strengthen the latissimus dorsi (LD) muscle, hence its name, and is also expected to activate the rhomboids, middle trapezius (MT), and biceps brachii (BB) muscles. There are several different variations of body position, grip width, and forearm orientation that can be employed. The bar can be pulled down in front of the face (anterior LPD) or behind the head (posterior LPD), the hands can be narrowly or widely spaced, and the radioulnar joint can be pronated or supinated. Yet research to determine the optimal variation of the LPD for particular muscle development is limited. Currently, much of the literature on the strength-building capacity of this exercise is based on personal beliefs and experiences (3,4,16), although a few investigations have used electromyography (EMG) to quantify the amount of activity in different muscles during different types of LPDs (10,12,14,15). These studies have provided several scientifically based weight training recommendations, but questions remain about the most effective combination of grip width and forearm orientation.

Research has led to the general consensus that the anterior LPD is preferred to the posterior LPD. Most studies comparing the activity of the LD under both conditions have found that the anterior LPD elicits greater muscle activation (by EMG) than the posterior LPD (11,12,14). Only 1 study failed to observe any significant difference in muscle activity between anterior and posterior LPDs (15). There have also been safety concerns that pulling down the bar behind the head puts the arm into horizontal abduction with excessive external rotation, placing unnecessary stress on the anterior shoulder (4,9,16). Functionally, it would also appear that the anterior LPD more closely mimics activities of daily living than the posterior LPD. Because of these past results and safety concerns, the current research investigation focused only on variations of the anterior LPD.

A wide grip front pull (anterior) has been proposed as the most effective LPD variation for the developing the LD (12). This claim is based solely on 2 EMG studies comparing a wide grip-pronated forearm position (wide-pronated [WP]) with a narrow grip–supinated forearm position (narrow supinated [NS]), which have found significantly greater LD activation with WP than NS (12,15). However, 1 EMG study failed to observe any significant difference in LD activity between WP and NS conditions (10). These contradictory results may be explained by 2 major differences in experimental design. Firstly, EMG was recorded during an isometric contraction (10) in contrast to EMG of concentric and eccentric phases of the LPD (12,15). Recording EMG during isotonic muscle actions provides a better assessment of the amount of muscle activity during a typical LPD exercise. Secondly, participants selected their own workload (10), with most performing at about 30–40% of 1 repetition maximum (1RM), whereas the workload was experimentally controlled in the other 2 studies at 10RM (12) and 70% of maximum voluntary contraction (MVC) (15). It is more valid to assess muscle activity at a level close to typical training workloads (e.g., 70% of 1RM as per American College of Sports Medicine (ACSM) guidelines [1] for strength training), rather than 30–40% of 1RM. These criticisms suggest that the observation of greater LD activity for the WP than the NS grip (12,15) is a more valid and reliable finding for providing isotonic exercise recommendations.

However, the recommendation that a wide grip is preferred over a narrow grip (12,13) cannot be directly drawn from the finding of an advantage of WP over NS. In addition to varying the grip width between conditions (7), the forearm orientation (pronation vs. supination) was altered too. Therefore, the benefit of WP over NS on LD activation could arise from grip width, forearm orientation, or some combination of the 2. Therefore, the goal of the current study was to resolve this dilemma by comparing all 4 possible combinations of grip width and forearm orientation in a fully balanced design: WP, wide supinated (WS), narrow pronated (NP), and NS. These combinations have not been previously tested, we only hypothesize that WP will activate LD more than NS. This study will also assess MT and BB, because these muscles are also believed to be trained during an LPD (9,10,14).

Methods

Experimental Approach to the Problem

Although the anterior WP grip has been recommended as the most effective and safest type of LPD (12), it is not clear whether this is because of the particular grip width or forearm orientation used, as previous studies have confounded these variables. The current study employed a balanced design to compare grip width (wide vs. narrow), forearm orientation (pronated vs. supinated), and any interaction, by testing WP, WS, NP, and NS anterior grips. The sequence of these conditions was randomized in an effort to negate any possible effects of practice or fatigue. To normalize grip width for different sized individuals, we standardized the grip width based on anthropometric measures. As with previous research, the biacromial diameter was used as the narrow grip width (10,12). There is no standard width for a wide grip. One study employed 150% of biacromial diameter (10), whereas another used the distance from the fist to the seventh cervical vertebrae (12). In an effort to use an anthropometric measure that relates to a wide-grip LPD, we employed 'carrying width.' This is the distance between the hands (left to right fifth metacarpophalangeal joint) when standing in the anatomical reference position. A standard LPD bar was used for all grips. To standardize the weight across conditions, 70% of 1RM was determined from participants performing a test of 1RM according to ACSM guidelines (1) at least 48 hours before testing. Because a previous study (12) found no significant difference for 10RM between WP and NS grips (<1 kg), we used a single 1RM test. Although the LPD is primarily used to develop the LD, it is also performed to train the MT and BB (9,10,14). Therefore, EMG signals were recorded from the LD, MT, and BB muscles. In accordance with previous research, the root mean square of each EMG signal (rmsEMG) was employed to quantify the average muscle activity (10,12,15). The rmsEMG for each participant and condition was then normalized to the rmsEMG of an isometric MVC. The normalized rmsEMG was then compared across conditions by using a 2×2 (width $\times$ orientation) repeated-measures analysis of variance (ANOVA) separately for each muscle. This experimental design permits an empirical test of which combination of grip width and forearm orientation elicits the most activity in the LD, MT, and BB.

Subjects

Participants were 12 men aged 19–30 with an average age = 22.7 ± 3.1 years. The participants' average mass was 85.86 ± 11.94 kg, and their average height was 1.82 ± 0.10 m. The average biacromial diameter for all participants was 0.40 ± 0.03 m, and the average carrying width was 0.76 ± 0.06 m. The average 1RM for all participants was 99.46 ± 19.58 kg. Participants were all free of known musculoskeletal problems of the upper body. This study only examined participants who were previously familiar with the LPD lift and currently lifted weights on a regular basis but were not competitive bodybuilders, weightlifters, or powerlifters. All subjects were tested during the 2008 fall semester at the Berks Campus of Pennsylvania State University. The Institutional Review Board for the use of human subjects of the Pennsylvania State University granted permission for this study. Participants signed an informed consent after being informed of the experimental risks of the study and before any data collection.

Equipment

Participants used a standard lat bar on the LPD station of a 4-Stack Multi-Jungle weight machine (Model SM40; Life Fitness, Schiller Park, IL, USA). An auditory quartz metronome (Model XB700; Franz Mfg. Co. Inc., East Haven, CT, USA) was used to provide a consistent cadence throughout the study. Disposable Ag–AgCl pregelled snap electrodes (EL501; BIOPAC Systems, Inc., Goleta, CA) were placed in pairs over the skin, and parallel to the fibers, of the LD, MT, and BB muscles. The LD electrodes were positioned obliquely (25° above the horizontal) and 0.04 m below the inferior angle of the scapula (6). The MT electrodes were placed 0.03 m lateral to the second spinous process of the thoracic spine with the electrodes placed parallel to muscle fibers (5). The second thoracic vertebra was located by palpating for the seventh cervical vertebrae and counting the spinous processes in a descending fashion until the second thoracic vertebrae was located and marked. If differentiating the seventh cervical vertebrea was problematic, the participant was instructed to bend the head forward to differentiate the most prominent cervical vertebrea from the first thoracic vertebra (13). The BB electrodes were placed one-third the distance from the cubital fossa to the acromion process (17). Ground electrodes were placed on the acromion process (1 electrode) and the spine of the scapula (2 electrodes).

The skin sites were initially prepared by shaving the hair and abrading the skin, before cleaning with an alcohol swab. The distance between the electrode centers was standardized at 0.0375 m. Three shielded lead sets (SS2; BIOPAC Systems Inc.) connected the electrodes to a 4-channel remote monitoring system (TEL100M-C; BIOPAC Systems Inc), which has an impedance of 2 MΩ and a common mode rejection ratio of 110 dB. All of the leads were taped in place with a loop on the skin and further secured with an elastic bandage around the participant's torso and upper arm to reduce interference and were examined for stability during a simulated pull-down. The remote monitoring system was connected to a data acquisition and analysis system (MP100; BIOPAC Systems Inc.). The experimenters controlled data acquisition and postprocessing via AcqKnowledge software (version 3.7.3 for Windows; BIOPAC Systems Inc.) running on a microcomputer. Data were collected at a sampling rate of 500 Hz, and the raw EMG signals were amplified by a gain set at 1,000.

Procedures

During the initial visit, the following anthropometric measurements were taken: height, weight, biacromial diameter, and carrying width. Biacromial diameter was measured from the lateral aspect of the left to the right acromion processes using anthropometric tape. Carrying width was measured by asking the participants to stand with the palm of their hands facing the sides of their legs. Then the participants were asked to supinate their radioulnar joints so that the palms faced forward, whereas the humeri were maintained beside the body (similar to the anatomical reference position). From this position, the carrying width was measured from the left fifth metacarpophalangeal joint to the right fifth metacarpophalangeal joint, using anthropometric tape. The carrying width was used as the wide grip (W), whereas the biacromial diameter was used as the narrow grip (N) in this study.

After recording the anthropometric measures, the exercise protocol was described. Although participants were familiar with an LPD exercise, the specific technique, inhalation and exhalation rhythm for lifting, and metronome pacing were prescribed. After ensuring that participants were comfortable performing the LPD as directed, a 1RM test was performed according to ACSM guidelines (1). The grip width for the 1RM was standardized with all participants placing the second phalanx on each hand at the bend in the bar with a pronated grip.

The EMG testing session took place at least 48 hours after initial testing, and the participants were instructed not to exercise until final testing was completed. The EMG equipment was set up and zeroed before being connected to the electrodes that were placed on each participant. The participants performed the 4 conditions (WP, WS, NP, and NS) in a random order, using 70% of 1RM load. The cadence of 2-second concentric and 2-second eccentric phases was prescribed by an auditory beep and visual flash of a metronome. Participants performed 2 trials of 5 repetitions for each condition before moving onto the next, with a 2-minute rest between each trial and condition.

The participants were again instructed visually and verbally how to perform an LPD. The thigh restraint pads were adjusted so the thigh and leg formed a 90° angle with the feet flat on the floor (8). The participants were instructed to be slightly extended at the hips to prevent any collisions with the bar and head and to pull the lat bar down in a straight vertical plane from a slightly flexed position to the participant's chin in a slow and controlled manner (9). The lat bar was lowered for them, and they remained seated for the entire testing session. Participants started with the elbows slightly flexed and the bar pulled down to the chin for all conditions. Although this meant the amplitude of the movements was not identical across conditions, it ensured the lifts were functionally equivalent. The movement was initiated with scapular depression and retraction, which was held throughout the length of the repetitions until the bar reached the resting position (4,9). The participants were then instructed to begin performing the lifts. The participants were told not to pause at each metronome beep, but slowly transition between the lifting and lowering phases, and requested to inspire on the eccentric, and expire on the concentric muscle actions. With participants performing the LPD correctly and at the right tempo, 5 repetitions were recorded, making up a 20-second trial. If a participant failed to perform correctly, the trial was repeated after a 2-minute rest.

After testing all conditions, participants performed an isometric maximum exertion. The isometric exercise was an LPD with the shoulders abducted $\pi/2$ rad and both elbows flexed $\pi/2$ rad. Participants placed the second phalanx on each hand at the bend in the bar, with a pronated grip, as done for the 1RM test.

Electromyographic Analyses

For each trial and muscle, the raw EMG signal was amplified by a gain of 1,000 and filtered using a 10-Hz high pass filter (PE). The filtered EMG signal was then smoothed and rectified by calculating the root mean square (rmsEMG) for

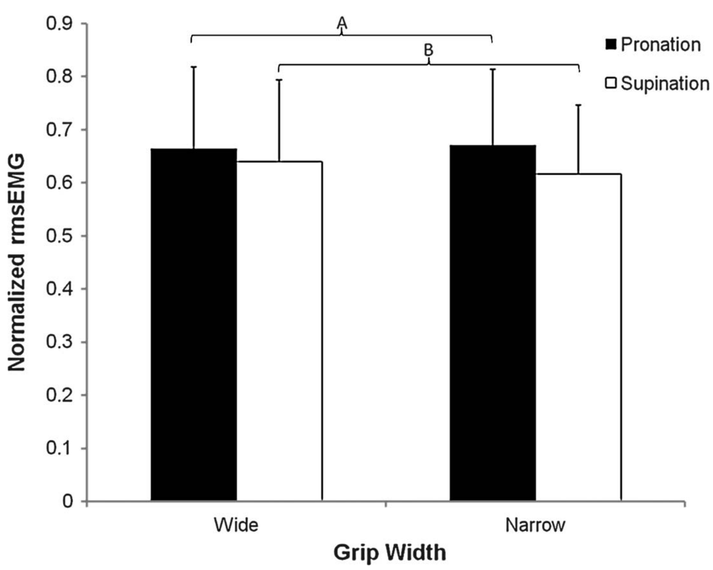

Figure 1. Mean ($n = 12$) normalized root mean square electromyography (NrmsEMG) for the latissimus dorsi (LD) during different grip widths (wide and narrow) and forearm orientations (pronated and supinated). The brackets A and B indicate a significant main effect of grip orientation (*$p < 0.05$), revealing that pronated grips produced greater LD activation than supinated grips, irrespective of grip width.

Table 1. Mean and *SD*s ($n = 12$) of NrmsEMG for LD, MT, and BB during WP, WS, NP, and NS.*

	WP	WS	NP	NS
LD	0.671† ± 0.142	0.617† ± 0.130	0.664† ± 0.154	0.640† ± 0.154
MT	0.578 ± 0.204	0.553 ± 0.211	0.537 ± 0.168	0.543 ± 0.171
BB	0.377 ± 0.098	0.424 ± 0.115	0.427 ± 0.151	0.434 ± 0.147

*NrmsEMG = normalized root mean square electromyography; LD = latissimus dorsi; MT = middle trapezius; BB = biceps brachii; WP = wide-pronated grip; WS = wide-supinated grip, NP = narrow-pronated grip; NS = narrow-supinated grip.
†Pronated grips produced greater activation than supinated grips ($p < 0.05$).

a 30-data sample moving window (0.06 seconds). The average rmsEMG was then computed for the 2 20-second trials under each condition. The raw EMG signal for each muscle during the maximal isometric contraction was processed in the same way as above, except that an average was computed for only 1 second of maximal activity to avoid effects of fatigue. To normalize the data (normalized root mean square of each EMG signal [NrmsEMG]), the average rmsEMG for each condition was divided by the average rmsEMG for the maximal isometric contraction.

Statistical Analyses

Normalized root mean square of each EMG signal was analyzed separately for each muscle by 32 × 2 (Width × Orientation) repeated-measures ANOVAs. All statistical procedures were performed using SPSS statistical software version 15.0 (SPSS Inc., Chicago, IL, USA), and the alpha level was selected as $p \leq 0.05$. Intraclass correlation coefficients (ICCs) were computed for NrmsEMG of each muscle separately. All 3 dependent variables indicated strong consistency (ICC 0.87, 0.85, and 0.76 for LD, MT, and BB muscles, respectively).

Results

No significant difference was found for LD activity between the wide and narrow grips ($p = 0.711$, power = 0.064). In contrast, there was a significant main effect for forearm orientation on NrmsEMG of the LD ($p = 0.012$, power = 0.776). The LD demonstrated greater activation during a pronated hand grip ($M = 0.67$) than a supinated hand grip ($M = 0.63$) (see Figure 1 and Table 1). The interaction of grip width and hand orientation had no significant effect on LD activation ($p = 0.185$, power = 0.253). The statistical analyzes of the NrmsEMG of MT and BB muscles revealed no significant main effects or interactions (see Table 1).

Discussion

In agreement with previous literature, a WP grip LPD elicited greater LD muscle activity than an NS grip LPD (12,15). However, our findings indicated this was because of using a pronated forearm orientation, not a wide grip width as proposed by others (12,15). Previous studies based their conclusions by comparing WP with NS, so that the results obtained could have been because of grip width, forearm orientation or a combination of the 2. To avoid this concern, we employed a fully balanced design to compare WP, WS, NP, and NS conditions. In contrast with prior recommendations, grip width did not significantly influence the LD, and neither was an interaction of grip width and orientation observed. The only significant finding indicated that the LD was more active under a pronated grip than a supinated grip. Hence, our results for identical conditions match previous studies of an isotonic LPD (12,15). The only findings they contradict are those for an isometric LPD, which found no differences in the LD between WP and NS grips (10). It would seem that results from an EMG analysis of isometric muscle actions are not necessarily applicable to an isotonic exercise.

The different types of grip failed to significantly influence the EMG data for the MT and BB muscles. These findings agree with an earlier study that compared WP with NS and failed to observe any significant difference in muscle activation (10), but as noted above, those findings were based on an isometric LPD. It might have been predicted that with a supinated grip the BB has a more efficacious angle of pull, but there is no training advantage for the BB between the different types of grip tested.

It is also useful to look at the amount of NrmsEMG for each muscle, which indicates the proportion of maximum activity and therefore provides an estimate of the relative activity of each muscle. On average, the LD was activated at 65% of an isometric MVC, whereas the MT and BB were activated at 55 and 42%, respectively. Because the LPD was performed using a load of 70% 1RM, these results would indicate that the LD was being activated at appropriate training levels. In contrast, it would seem that both the MT and BB were activated at lower levels. This suggests that all 4 grip types primarily activated the LD, and to a lesser extent the MT and BB. Therefore, an LPD is best employed to strengthen the LD and is not an optimal exercise for developing the MT or BB muscles.

We hypothesize that the LD is more active during a pronated grip vs. a supinated grip because of a greater joint moment at the shoulder. Previous research has suggested that a WP grip involves greater abduction and horizontal abduction than an NS grip, which in turn leads to more LD activity (12). However, the finding here that grip width had no significant effect on the electrical activity of the muscles contradicts this proposal. With the LD being less active during a supinated grip, it might be expected that other muscles would compensate by being more active. Surprisingly, both MT and BB were active at similar levels for all 4 grips. Also, in another EMG study, which compared WP and NS grips, none of the muscles (pectoralis major, posterior deltoid, triceps brachii, and teres major) assessed were more active during an NS grip. These findings suggest that a pronated grip places the shoulder at a mechanical disadvantage that requires greater LD activity but does not affect the MT or BB muscles. A biomechanical analysis of joint moments during a pull-up (2) provides an explanation for our results. The analysis revealed that using a pronated grip leads to a larger overall perpendicular distance between the shoulder joint and pull-up bar than a supinated grip, causing a greater joint moment at the shoulder. In addition, the wrist and elbow joints, and shoulder girdle were not found to be significantly involved during the pull-up, nor were they influenced by the forearm orientation. Because the pull-up is similar to the LPD, we propose that a pronated LPD grip creates a larger joint moment at the shoulder than a supinated grip, which in turn requires greater LD activity to lift the same load.

Practical Applications

With the main goal of an LPD being to develop the LD muscles, it is important to know which variation best activates this muscle. The findings from this study indicate that a pronated grip is optimal for training the LD in an anterior LPD. Contrary to the claim that a wide grip is best (12,15), the findings here show that there is no difference between narrow and wide grip widths with a pronated grip orientation. Prior research has identified safety concerns and reduced LD muscle activity for a posterior LPD (12). Taking these results together, we conclude that an anterior LPD with a pronated grip is recommended for safely and optimally training the LD, irrespective of the grip width (either carrying width or biacromial diameter). Although the MT and BB were active at similar levels for the different grip types of LPD, other exercises are likely to better train these muscles.

Acknowledgments

This study was funded by a Division of Science Undergraduate Research Grant, The Pennsylvania State University Berks, Reading, PA.

References

1. American College of Sports Medicine. *ACSM's Guidelines for Exercise Testing and Prescription.* (7th ed.). Philadelphia, PA: Lippincott, Williams, & Wilkins, 2006.
2. Antinori, F, Felici, F, Figura, F, Marchetti, M, and Ricci, B. Joint moments and work in pull-ups. *J Sports Med Phys Fitness* 28: 132–137, 1988.
3. Baechle, TR and Earle, RW. *Essentials of Strength Training and Conditioning Resistance Training.* (2nd ed.). Champaign, IL: Human Kinetics, 2000.
4. Crate, T. Analysis of the lat pull down. *J Strength Cond Res* 19: 26–29, 1996.
5. Ekstrom, RA, Soderberg, GL, and Donatelli, RA. Normalization procedures using maximum voluntary isometric contractions for the serratus anterior and the trapezius muscles during surface EMG analysis. *J Electromyogr Kinesiol* 15: 418–428, 2004.
6. Escamilla, RF, Babb, E, Dewitt, R, Jew, P, Kelleher, P, Burnham, T, Busch, J, D'Anna, K, Mowbray, R, and Imamura, RT. Electromyographic analysis of traditional and nontraditional abdominal exercises: Implications for rehabilitation and training. *Phys Ther* 85: 656–671, 2006.
7. Funk, DA, An, KN, Morrey, BF, and Daube, JR. Electromyographic analysis of muscles across elbow joint. *J Orthop Res* 5: 529–538, 1987.
8. Graham, JF. Front lat pulldown. *Strength Cond J* 25: 42–43, 2003.
9. Lantz, J and McNamara, S. Modifying the latissimus pull-down exercise for athletes with shoulder injury. *Strength Cond J* 25: 67–69, 2003.
10. Lehman, GJ, Buchan, DD, Lundy, A, Myers, N, and Nalborczyk, A. Variations in muscle activation levels during traditional latissimus dorsi weight training exercises: An experimental study. *Dyn Med* 3: 4, 2004.

11. Pugh, GM. A biomechanical comparison on the front and rear lat pull-down exercise. Master's thesis, University of Florida, Gainesville, 2003.
12. Signorile, JF, Zink, A, and Szwed, S. A comparative electromyographical invesigation of muscle utilization patterns using various hand positions during the lat pull down. *J Strength Cond Res* 16: 539–546, 2002.
13. Smith, LK, Weiss, EL, and Lehmkuhl, LD. *Brunnstrom's Clinical Kinesiology.* (5th ed.). Philadelphia, PA: F. A. Davis, 1996.
14. Tooru, H, Hiroto, K, Shin, H, Jun'ichi, O, and Kiyotada, K. Comparative electromyographical investigation of the biceps brachii, latissimus dorsi, and trapezius muscles during five pull exercises. *Jpn J Phys Fitness Sports Med* 54: 159–168, 2005.
15. Wills, R, Signorile, J, Perry, A, Tremblay, L, and Kwiatkowski, K. Differences in EMG activity due to handgrip position during the lat pulldown. *Med Sci Sports Exerc* 26: S20, 1994.
16. Yessis, M. Front lat pull-down. *Muscle Fitness* March: 37–39, 1997.
17. Zipp, P. Recommendations for the standardization of lead positions in surface electromyography. *Eur J Appl Physiol Occup Physiol* 26: 41–54, 1982.