Electromyographic Analysis of Three Different Types of Lat Pull-Down

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Abstract

Sperandei, S, Barros, MAP, Silveira-Júnior, PCS, and Oliveira, CG. Electromyographic analysis of three different types of lat pull-down. *J Strength Cond Res* 23(7): 2033–2038, 2009—The purpose of this work was to evaluate the activity of the primary motor muscles during the performance of 3 lat pull-down techniques through surface electromyography (EMG). Twenty-four trained adult men performed 5 repetitions of behind-the-neck (BNL), front-of-the-neck (FNL), and V-bar exercises at 80% of 1 repetition maximum. For each technique, the root mean square from the EMG signal was registered from the pectoralis major (PM), latissimus dorsi (LD), posterior deltoid (PD), and biceps brachii (BB) and further normalized in respect to that which presented the highest value of all the techniques. A series of two-way repeated measures analysis of variance was used to compare the results, with Tukey-Kramer as the post hoc test and $\alpha = 0.05$. During the concentric phase, PM value showed the FNL to be significantly higher than V-bar/BNL and V-bar higher than BNL. During the eccentric phase, FNL/V-bar was higher than BNL. For LD, there was no difference between techniques. PD presented BNL higher than FNL/V-bar and FNL higher than V-bar in the concentric phase and BNL higher than V-bar in the eccentric phase. BB exhibited BNL higher than V-bar/FNL and V-bar higher than FNL in both concentric and eccentric phases. Considering the main objectives of lat pull-down, we concluded that FNL is the better choice, whereas BNL is not a good lat pull-down technique and should be avoided. V-bar could be used as an alternative.

Key Words electromyography, resistance training, shoulder

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Introduction

Resistance training has become the subject of an increasing number of scientific studies, and more research in strength training has been done between 1987 and 1997 than in the previous 50 years (10). One of the main goals of such research is to increase the efficacy and safety of the exercises performed. However, finding the right balance between these 2 aspects is a challenge for those who work in this area. Thus, the manner in which the exercises are performed has constantly been reviewed, looking for possible risks associated with these exercises and ways of improving the results. When the existence of an important risk factor in an exercise is detected, this is considered "contraindicated" and, as a consequence, safer alternatives have to be indicated (8). The full squat and lateral trunk bend while standing can be used as examples.

Recently, the behind-the-neck lat pull-down (BNL) exercise has been criticized because of its potential risk to the shoulder joint (8,12,18,19). The external rotation combined with abduction (Figure 1) places the shoulder joint in a risk position because it minimizes the stabilization capacity of the rotator cuff and places the glenohumeral ligaments under great stress (8,18,19). This situation is worsened by horizontal abduction, which is needed to avoid the contact between the exercise bar and the head of the practitioner. On the other hand, when performed in front-of-the-neck (FNL), a lat pull-down is executed in the scapular plane (Figure 2) where there is more contact within the articular surfaces, lower stress of the glenohumeral ligaments, and a better function of the rotator cuff muscles (11,14). This technique has been used to replace the BNL, being safer, more functional, and allowing for a wider range of motion (ROM) (8). Another possible variation of this exercise is replacing the common straight bar used by a V-bar (Figure 3). This bar allows a pulling down with the elbows at the sides, preventing horizontal abduction of the shoulder. Signorile et al. (22) compared BNL and FNL using eletromyography and generally found that although FNL was not more efficient than BNL, no significant difference was observed. Carpenter et al. (6) also compared BNL and FNL electromyographically and found no differences between

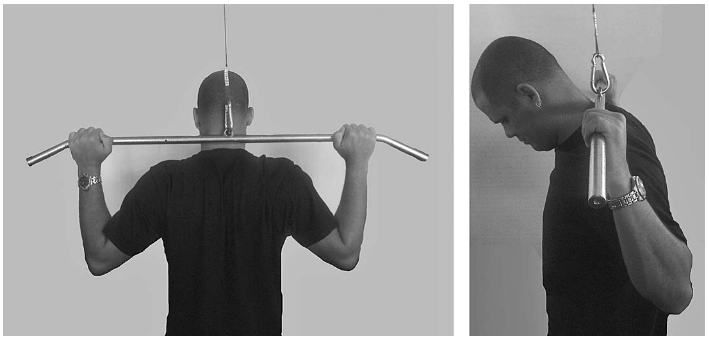

Figure 1. Behind-the-neck lat pull-down (BNL). Frontal (left) and sagital (right) planes. Note elbows behind body, emphasizing horizontal abduction of shoulder.

these 2 techniques, with the exception of the trapezius muscle, which was more active in BNL. As far as the present authors are aware, no research has been done regarding electromyography (EMG) activity of the lat pull-down using the V-bar as described above.

It is important to gain knowledge about the effect of BNL, FNL, and V-bar on the primary muscle activity to improve the efficacy and safety of the exercise prescription. Furthermore, little information can be found in the literature regarding shoulder adduction accomplished in external rotation, as in lat pull-down, whereas the latissimus dorsi and pectoralis major are muscles that present a strong EMG activity during shoulder adduction (3,20,21). In addition, the posterior deltoid can act as an adductor, especially when the arm is rotated laterally (4). Thus, one might expect that investigating the activity of the main muscles involved in the lat pull-down would be of great importance in such a subject, although only 2 previous studies (6,22) appear to have been published for this kind of exercise.

The purpose of the present work was to compare the BNL, FNL, and V-bar techniques of the lat pull-down exercises with regard to the muscle activity of the pectoralis major, latissimus dorsi, posterior deltoid, and biceps brachii through surface EMG.

Methods

Experimental Approach to the Problem

To compare the EMG response between different lat pull-down techniques, subjects performed 5 repetitions of 3 techniques of the exercise, with surface electrodes positioned over the 4 muscle bellies (pectoralis major, latissimus dorsi, posterior deltoid, and biceps brachii). The techniques chosen (BNL; FNL; and behind-the-neck with V-bar –[V-bar]) are common in weight training rooms. BNL has been associated with risk of injury, but to replace this exercise by another, it is important to assess the capacity of the other exercises to challenge the primary muscles.

Subjects

Twenty-four young male subjects (26 $\pm$ 4 yr) volunteered for this study. They were all experts in weight training, with a minimum of 1 year of practice with the selected exercises. Before participation, all the subjects provided a signed informed consent form in agreement with resolution 196/96 of the National Council of Health (*http://conselho.saude.gov.br/docs/Reso196.doc*). The main anthropometric characteristics of subjects are summarized in Table 1.

Data Collection

On the first day, the subjects were submitted to a physical evaluation including body composition according to Jackson and Pollock (13), height, weight, biacromial distance, and strength (1 repetition maximum –[1RM]) assessment. The 1RM test was performed as previously described (23). In summary, the hand grip was marked on the bar, allowing a between-hands distance equal to 1.6 times the biacromial distance. After each successful attempt, 5 kg were added to the load until a failure occurred. Then, the load was decreased by 3 kg, and a last attempt was performed, observing a 5 minute rest between each attempt. This protocol was reported to present a between-days systematic error lower than 3 kg, with a 95% limits of agreement of

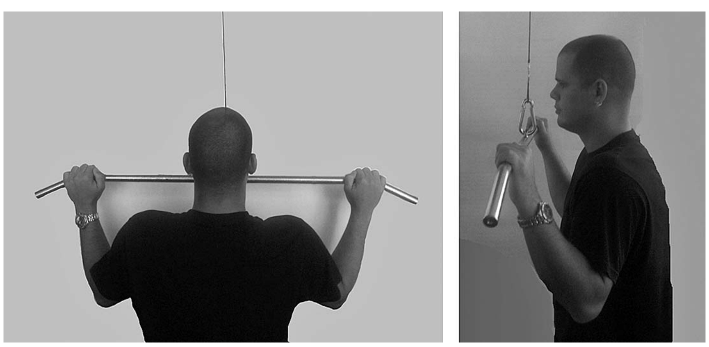

Figure 2. Front-of-the-neck lat pull-down (FNL). Frontal (left) and sagital (right) planes. Note elbows in front of body, emphasizing movement in scapular plane.

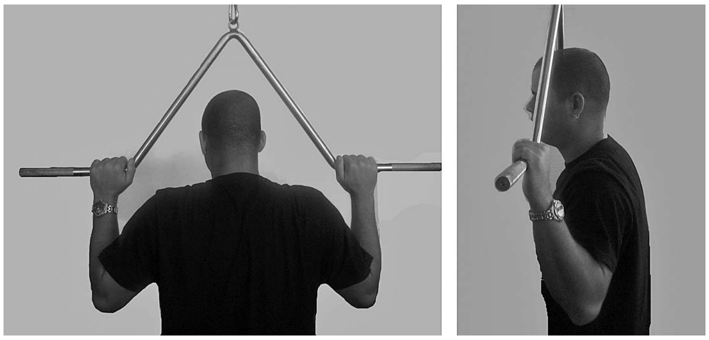

Figure 3. Lat pull-down with V-Bar (V-bar). Frontal (left) and sagital (right) planes. Note elbows at side of body, emphasizing movement in frontal plane.

4.9 kg (23). The 1RM strength test was executed only for the FNL technique, and the highest load lifted by the subject was used for all variations (FNL, BNL, and V-bar).

The EMGs of the pectoralis major, latissimus dorsi, posterior deltoid, and biceps brachii muscles were evaluated during the lat pull-down exercises on the second day, which was from 48 to 72 hours after the first day. The electrode sites were selected in accordance with Cram and Kasman (7), and, before the placement of the electrodes, the areas were shaved and cleaned with alcohol until a slight redness was apparent. The EMG was captured through disposable surface electrodes (Kendal Medi Trace 200, Tyco Healthcare, Pointe-Claire, Canada), which were placed over the muscle bellies. EMG signals were collected using an ME3000P8 EMG system (Mega Electronics, Ltd., Kuopio, Finland). The total gain of the amplifier was set at 1,000 with a common mode rejection ratio of 92 dB. The signal was sampled at 1,000 Hz after band pass was filtered at 10 to 500 Hz.

After this, each subject performed 3 sets of 5 repetitions with 80% of individual 1RM load. Each set was performed with a different lat pull-down technique (BNL, FNL, and V-bar), the order of performance being randomly selected. The cadence of execution was set at 2 seconds/phase, with the help of a digital metronome. A rest period of 10 minutes was allowed between sets. Any event during the test was marked manually into the EMG system, which included the concentric and eccentric phases of the exercises. The EMG signals from the first and last repetitions were discarded to avoid interference present at the beginning and end of the exercise (1). Thus, only the EMG signals of the 3 central repetitions were analyzed after being fully rectified. Further, the root mean square values of consecutive 100 samples of each phase and repetition were calculated, and the mean was used as a value for each phase and technique. The phase and technique with higher EMG values were used as an individual reference, and the remaining values were expressed as a percentage of this maximum (24). The reliability of all these procedures was assessed elsewhere (2), with good reliability being reported, with typical errors related to execution varying from 5–10%.

TABLE 1. Main anthropometric and strength characteristics of sample

	Age (yr)	Weight (kg)	Height (cm)	Body fat (kg)	1RM (kg)
Mean	26	78	178	11.7	100
SD	4.0	9.4	7.09	3.19	14.5

*1RM = 1 repetition maximum.

Statistical Analyses

A series of independent two-way repeated measures analysis of variance was used to compare the EMG response in each muscle with technique and phase (eccentric and concentric) as factors. The Tukey-Kramer post hoc test was used when appropriate. The significant level was set at 0.05.

Results

No statistical difference was observed when comparing the 3 sets arranged in order (Figure 4), meaning that learning or fatigue have no effect on EMG response. The results of the pectoralis major muscle (Figure 5) showed significant differences related to both technique performed ($p < 0.001$) and phase ($p < 0.001$), with a significant interaction between them ($p < 0.001$). During the concentric phase, the FNL was more active than V-bar and BNL, and V-bar was more active than BNL. However, during the eccentric phase, no differences among FNL, V-bar, and BNL were found.

Latissimus dorsi muscle activity did not show a technique effect ($p = 0.777$), but the concentric phases showed higher EMG values than the eccentric phase ($p < 0.001$), with no interactions ($p = 0.776$).

The EMG signal from the posterior deltoid muscle showed significant effect of the technique ($p < 0.01$) and phase ($p < 0.001$), with significant interactions ($p < 0.05$). Activity was

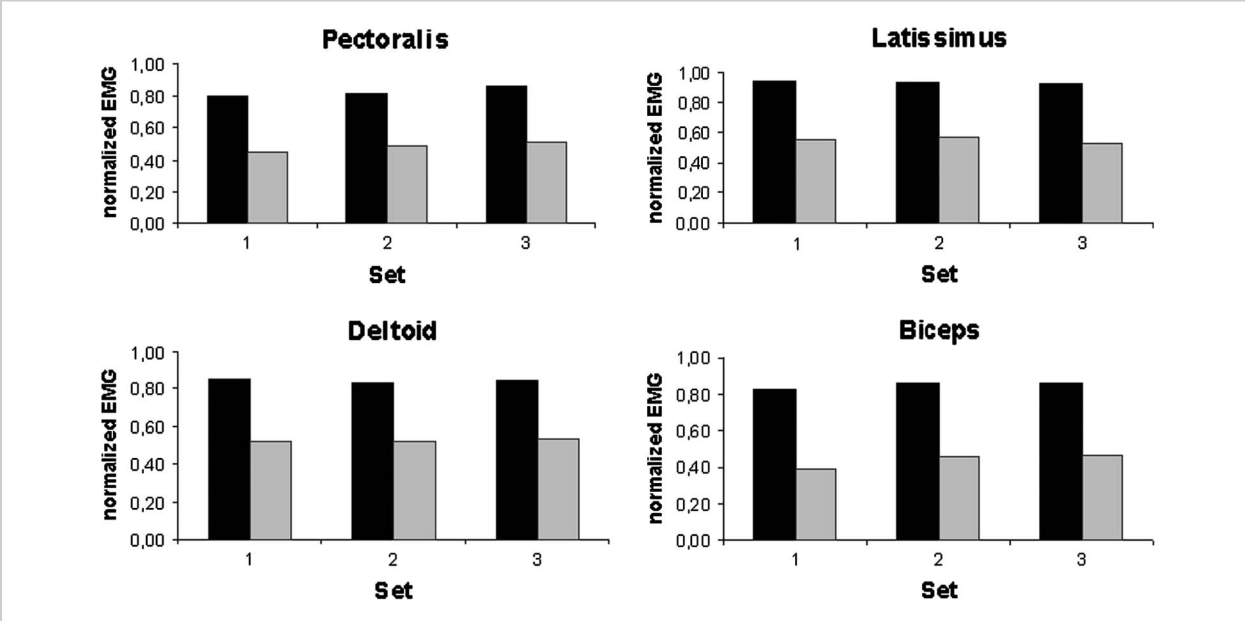

Figure 4. Mean normalized root mean square of concentric (black) and eccentric (gray) phases arranged by order of execution of each of 3 sets. No differences between sets was found, but significant differences ($p < 0.001$) between concentric and eccentric phases in all sets was found.

higher at BNL than FNL and V-bar, and FNL was higher than V-bar at the concentric phase. During the eccentric phase, only BNL was more active than V-bar.

The results of the biceps brachii muscle showed a significant effect of technique ($p < 0.001$), phase ($p < 0.001$), and interaction ($p < 0.01$). The biceps muscle showed an opposite pattern when compared with the pectoralis major concentric phase, with BNL higher than FNL and V-bar and V-bar being higher than FNL. The analysis of the eccentric phase showed a similar pattern.

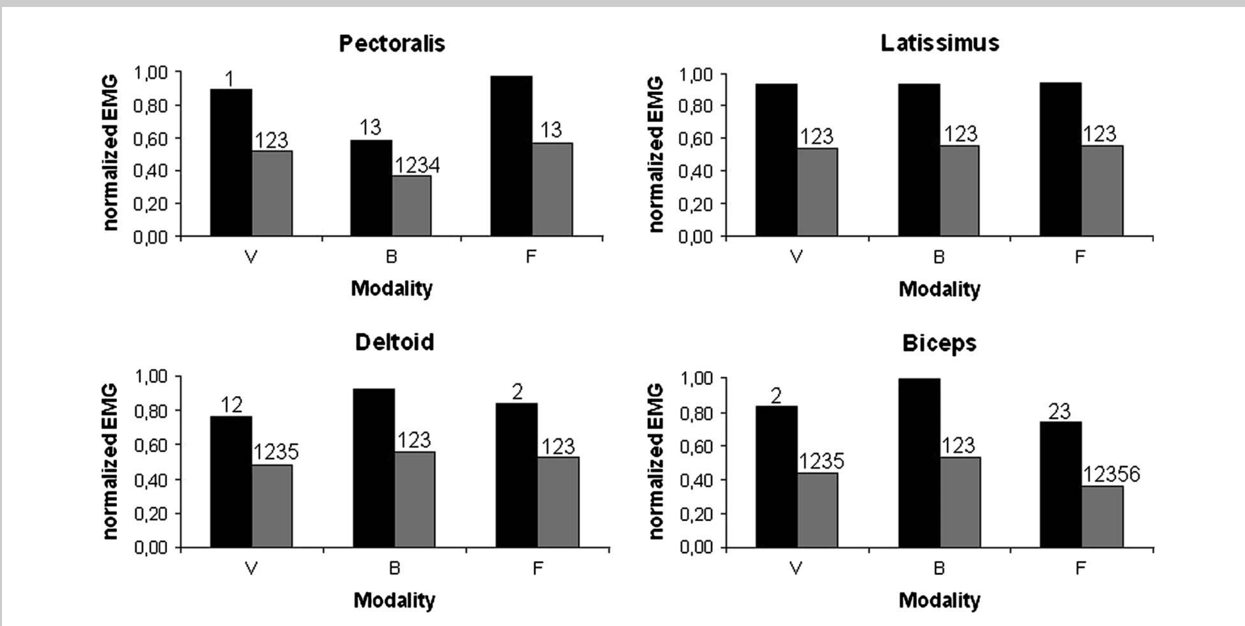

Figure 5. Mean normalized root mean square of concentric (black) and eccentric (gray) phases. V = V-Bar; B = behind-the-neck; F = front-of-the-neck. 1) Lower value than concentric F. 2) Lower value than concentric B. 3) Lower value than concentric V. 4) Lower value than eccentric F. 5) Lower value than eccentric B. 6) Lower value than eccentric V.

Discussion

This study investigated the muscle activity during lat pull-down exercises, whereas just 2 studies with similar areas of interest appear to have been previously published (6,22). Whereas latissimus dorsi and pectoralis major are muscles that have been reported as presenting a strong EMG activity during shoulder adduction (3,20,21), there is little information regarding the movement accomplished in an external rotation of the shoulder, as in a lat pull-down. The latissimus dorsi muscle is a potent adductor, extensor, and internal rotator of the arm (3,20,21), also participating as a horizontal abductor. Jonsson et al. (15) found activity in such muscle during adduction only when accomplished behind the body, being inactive in most of the cases where movement was performed in front of the body. However, in those studies, the movements were performed starting from anatomic position, without additional load, being very different from the exercise analyzed here. Bogduk et al. (5) showed that the better position to latissimus dorsi action is with arm flexed or abducted, which was not the case in the work of Jonsson et al. (15). Signorile et al. (22), when comparing 2 techniques as investigated in the present work (FNL × BNL), found latissimus dorsi more active during FNL, both concentrically and eccentrically. These results disagree with that of the present study, where difference was not observed in the EMG activity from latissimus dorsi in any of the phases, as found also by Carpenter et al. (6).

Pectoralis major is also a potent adductor, extensor, and medial rotator of the arm (3,20,21), although those functions are usually ignored in favor of the flexor and horizontal flexor. Jonsson et al. (15) described similar results to latissimus dorsi in behind-the-body adduction, but just the pectoralis major demonstrated EMG activity during front of the body adduction. This appears to be associated with the above-mentioned action as a flexor and horizontal flexor. Signorille et al. (22) described the pectoralis major as being more active during FNL, but just in the concentric phase. Their results agree with ours and disagree with those of Carpenter et al. (6), who found no difference in pectoralis major.

The deltoid muscle is always associated with shoulder abduction, but the posterior deltoid as a participant in shoulder adduction has also already been described (4,16,21) and was observed specifically in lat pull-down by Signorile et al. (22), who found more EMG activity at FNL compared with BNL. Our results showed the posterior deltoid to be more active during BNL than FNL. The EMG activity from biceps brachii during lat pull-down was evaluated previously only by Carpenter et al. (6), who did not find any difference between BNL and FNL. Our results, however, show an inverse pattern from that presented by pectoralis major, with BNL being higher than the other 2 techniques, whereas FNL presented the lowest difference.

Because no other work studied the V-bar technique, it is not possible to compare our results with a previous report. It should be pointed out that the V-bar described here is completely different from that used by Signorile et al. (22). In this study, V-bar represents a wide grip with an adduction movement, whereas in Signorile et al. (22), V-bar is a closed grip with an extension movement. From the EMG signals collected here, we can classify V-bar as an intermediate technique, between BNL and FNL. This is reinforced by the fact that V-bar is performed with the shoulder in the frontal plane, whereas FNL uses the scapular plane, and BNL is an adduction with horizontal adduction.

The differences between our results and those of Signorile et al. (22) and Carpenter et al. (6) could be caused by methodologic approaches. The distance between hands varied from 1.6 times the biacromial distance in the present study to 2 times in Signorile et al. (22) and was not described by Carpenter et al. (6). This distance could influence the ROM of the exercise and the EMG signal. Crate (8) suggested that FNL presents a higher ROM compared with BNL because a wider grip is needed during BNL. The load used could be another source of difference because, in this work, we used the same load for all techniques, which was assessed at FNL. Signorile et al. (22) used a specific load but described no statistical difference in loads applied in FNL and BNL, similarly to Carpenter et al. (6). Furthermore, in this last work, the 1RM load was not assessed but was predicted by equations.

Observing our results, we can hypothesize that FNL elicits higher activity from pectoralis major. Because the shoulder would be horizontally extended, the activity of this muscle would be gradually reduced until BNL. Because the same load is used in all techniques, activity in other muscles would supply the deficits, following the muscle equivalent concept (17).

Despite the differences between the results, with respect to the main goals of the exercise (strength increase of pectoralis and latissimus), all studies agree that FNL elicits equal or higher muscle activity than BNL. Also, the accessory goals to the exercise prescription of lat pull-down were more active in BNL in the present study. Because there is a theoretical risk associated with BNL, although there is no strong evidence of a relationship between BNL and shoulder injury, as shown by cohort studies, it appears that BNL is unnecessary and should be avoided, which agrees with Fees et al. (9). Moreover, there is no sport or daily activity that elicits movement patterns even similar to BNL (8), whereas FNL has many sport-specific applications (8,9). It appears then that the correct question is not, "why not do BNL?", but "why do BNL?"

Practical Applications

The results from this study reinforce the substitution of BNL by FNL because the latter showed higher activity when one takes into account the principal goals of the exercise. BNL elicited more activity only for muscles that, in general, are not the principal target. Usually, the practitioners of weight training link the BNL with a greater recruitment of latissimus dorsi. On the other hand, the FNL is linked to a better workout for pectoralis major. Although the last statement was confirmed by our results, the first was not, neither here nor in any published work.

If the objective is to work only latissimus dorsi, the practitioner can use any of the 3 exercises analyzed here. However, the BNL has a potential risk associated with it. So far, this risk is only theoretical, but it does exist. Because there is no advantage in using the BNL in relation to functional use (there is no movement in which a load is pulled behind the neck) or the recruitment of the main muscles involved, the FNL is a more recommended option. To those who want to use BNL, we recommend the use of a V-bar, which reduces the risks of BNL and is as efficient, or more so, than BNL for its purpose.

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