The Influence of Bar Diameter on Neuromuscular Strength and Activation: Inferences from an Isometric Unilateral Bench Press

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Abstract

The purpose of this study was to examine the influence of two different bar diameters on neuromuscular activation and strength. The bar diameters used reflected a standard Olympic bar (28 mm (1.1 inch); THIN) and a larger fat bar (51 mm [2 inch]; THICK). Eighteen healthy men (age 25.0 ± 1 years) were assessed for their maximal voluntary contraction (MVC) during a unilateral isometric bench press exercise with the 2 bar types at 2 different joint angles (angle 1 and angle 2; elbow joint at ~45 and 90°, respectively). Additionally, on a separate day, subjects performed three 10-second isometric repetitions at an intensity of 80% MVC using the 2 different bars at angle 1 and angle 2. Electromyographic recordings were collected in the pectoralis major and the muscles of the forearm flexor region at a sampling rate of 1000 Hz during the second day of testing. Analysis of variance was used to examine differences in MVC between bars and also examine between bar differences in electromyographic activity for each muscle group at each joint angle. A significance level of 0.05 was used for all tests. MVC was not different between bar types, although there was a main effect of joint angle on MVC such that it was greater at angle 2. There was a main effect of bar at both angles for the forearm muscles and at angle 1 for the pectoralis such that electromyographic activity was greater with THIN. Our data do not support the hypothesis that bar diameter influences performance during an isometric bench press exercise. However, higher electromyographic activity with THIN suggests greater neuromuscular activation with a standard Olympic bar as opposed to a larger diameter "fat" bar. Although our data do not support the use of a fat bar for increasing neuromuscular activation, these findings should be confirmed in other resistance training exercises.

Key Words electromyography, maximal voluntary contraction, resistance training, fat bar

Introduction

Strength and conditioning specialists are continually searching for strategies and techniques to aid in the development optimal training programs to maximize athletic performance. One recent trend in strength training has been the manipulation of traditional exercises with the use of different equipment. Specifically, there is a growing interest in altering the size and shape of the gripping component of standard lifting bars (4,5). Although there is limited research in this area, a few investigators have reported that alterations in bar diameter and shape do, in fact, alter performance (3,5,6,9,10).

Grant et al. (6) examined three different handle diameters at three different levels of resistance in order to evaluate the effects of handle diameter on neuromuscular strength and activation during a simulated industrial task. They found that the smallest handle diameter (1 cm smaller than the user's inside grip diameter) elicited the greatest maximal voluntary contraction (MVC), while the smallest handle diameter also resulted in the lowest neuromuscular activation as assessed by electromyography (EMG). Additionally, Petrofsky et al. (9) and Blackwell et al. (3) both reported maximal handgrip force production occurs at an intermediate handgrip span. Last, Drury et al. (5) tested isometric muscular endurance using either a standard Olympic bar with a circular grip or a tri-bar, a bar with a triangle-shaped grip. They reported that subjects exhibited an increase in muscular endurance during a straight-arm body weight hang using the tri-bar. The authors subsequently concluded that the tri-bar may be an effective alternative to a standard bar for increasing isometric endurance with regard to exercises that require isometric grasping.

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22(3)/661–666

Journal of Strength and Conditioning Research

Accordingly, some strength coaches are now touting the use of a "fat" bar for its possible favorable influence on muscle activation and strength gains (4). The fat bar is the same length and has the same circular shape as a standard Olympic bar, but the gripping portion has a greater diameter. It measures 51 mm (2 inches) in diameter as opposed to a standard Olympic bar diameter of 28 mm (1.1 inches). Proponents for the thicker bar claim that the oversized grip elicits greater muscle activation, especially within the forearm muscle group, therefore enhancing the strength of the muscles used for the exercise (4). However, we were only able to find 1 study to date that examined the influence of bar diameter on performance during traditional strength training exercises. In this study, Ratamess et al. (10) reported that 2- and 3-inch bar diameters significantly reduced muscular strength during several resistance training exercises. Unfortunately, however, the authors did not measure electromyographic activity to gain insight into how the bar diameters influenced neuromuscular activation.

Therefore, the purpose of this study was to examine the influence of two different bar diameters (28 vs. 51 mm) on neuromuscular activation and strength. Electromyographic recordings were collected in the pectoralis major and the forearm flexor muscles (flexor digitorum superficialis and flexor digitorum profundus) during a unilateral isometric bench press exercise at an intensity of 80% of maximum. The bench press exercise was chosen because it is one of the most heavily used resistance training exercises by strength and conditioning specialists for the development of upper body strength and also because it allows the examination of multiple muscle groups. In accordance with the work of Grant et al. (6), it was hypothesized that the thicker bar would elicit greater muscle activation in the muscle groups examined.

METHODS

Experimental Approach to the Problem

A repeated-measures design was used to test the hypothesis that bar diameter influences neuromuscular activation and strength during an isometric unilateral bench press exercise. Subjects performed unilateral isometric maximal voluntary contractions (MVCs) at 2 different joint angles using 2 bars of different diameters. Furthermore, neuromuscular activation was assessed via electromyographic recordings collected during 3 isometric contractions at both angles using the 2 different bars. Electromyograms were recorded during contractions performed at 80% of MVC in an attempt to simulate high-intensity contractions commonly used in strength and conditioning programs. Independent variables included bar type, joint angle, and repetition. The 2 bar types used in this study reflect the diameter of a standard Olympic bar and that of a larger fat bar, whereas the 2 joint angles reflect angles within the normal range of motion of the bench press exercise. We further chose to examine electromyographic activity during 3 repetitions to determine whether our results could be influenced by any fatigue that may have occurred by performing multiple repetitions. Our dependent variables included MVC and the root mean square (RMS) of electromyographic activity. MVC was used as an indicator of isometric strength, whereas RMS is a standard index of electromyographic amplitude and generally reflects overall neuromuscular activation (8).

TABLE 1. Descriptive statistics of the subjects: data are mean ± *SE* ($n = 18$).

Age (years)	Weight (kg)	Height (cm)	Body fat (%)
25.0 ± 1	78.6 ± 4	176.3 ± 2	11.2 ± 1

Subjects

Eighteen college-age men were recruited and completed the study requirements. Descriptive statistics of the subjects are shown in Table 1. This number of subjects was determined to yield 80% power via an a priori power analysis. Inclusion criteria were (a) age 18–30 years, (b) no documented neuromuscular, cardiovascular, or metabolic disease, and (c) at least 1 year of consistent weight-training experience at least twice weekly in which they had to be proficient in the bench press exercise. All procedures were approved by the University's Committee for the Protection of Human Subjects, and all subjects gave written informed consent before participating in the study.

Procedures

Each subject reported to the Exercise Physiology Laboratory on 2 days separated by at least 1 week. Subjects were asked to refrain from consuming caffeine and any other stimulants and also to refrain from strenuous exercise during their designated testing days. The protocols for each of the testing day were as follows.

Day 1. After giving written informed consent, subjects were assessed for height and weight using a standard physician's scale. Lange skinfold calipers were used to perform a 7-site

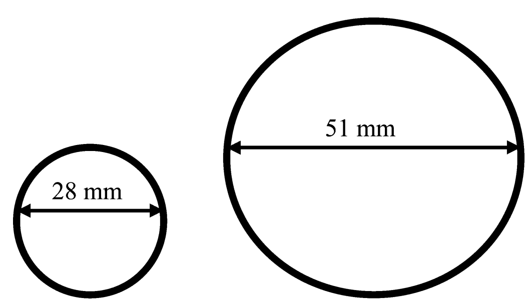

Figure 1. Diagram of the 2 different bars used in the study.

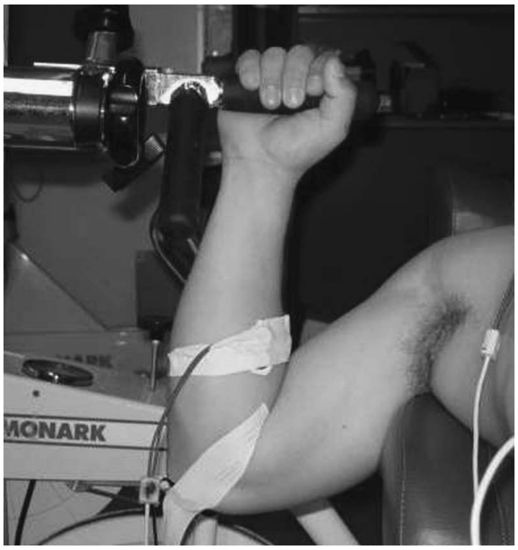

Figure 2. Joint angle 1.

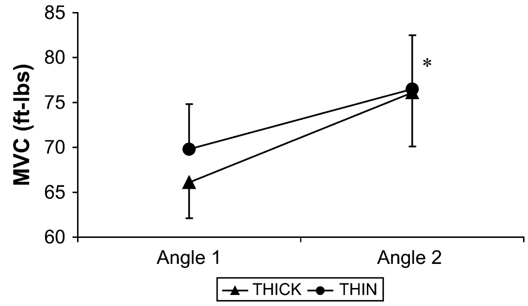

Figure 4. Maximal voluntary contraction for the 2 bars at angles 1 and 2. *$p < 0.05$ versus angle 1; main effect of angle.

estimate of body density, which was subsequently reported as the percentage of body fat using standard prediction equations (1). All subjects were then fitted properly on a Biodex System 3 Dynamometer (Biodex, Shirley, NY). Subjects were placed in the supine position with Velcro straps placed over their torso to ensure minimal body movement. Subjects were positioned with the bar handle located at the nipple line of the chest to simulate, as closely as possible, a supine bench press position. Each subject performed 3 maximal isometric presses with their dominant arm at 2 different shoulder joint angles using the standard bar grip (28-mm (1.1-inch) diameter; THIN) and the thick bar (51-mm (2-inch) diameter; THICK) (Figure 1).

The 2 shoulder joint angles tested simulated joint angles involved during a supine free-weight bench press. In the first position, the bar was placed near the top of the subject's chest and the elbow joint was approximately 45° (angle 1; Figure 2). This position placed the pectoralis major in the lengthened state. In the second position, the bar was placed off the chest with the shoulder joint parallel to the elbow joint and the elbow joint at 90° (angle 2; Figure 3). A randomized selection process determined the order in which the subjects used each bar and the order of each angle. For each bar and each angle, the subjects pressed maximally for 5 seconds and rested for 3 minutes between each of the 3 repetitions. After 3 maximal

Figure 3. Joint angle 2.

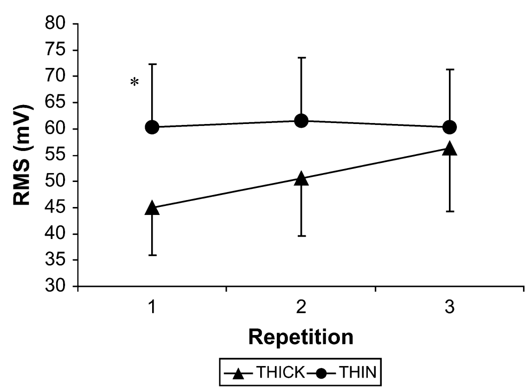

Figure 5. Root mean square for the 2 bars in the pectoralis major at angle 1. *$p < 0.05$ versus THICK; main effect of bar.

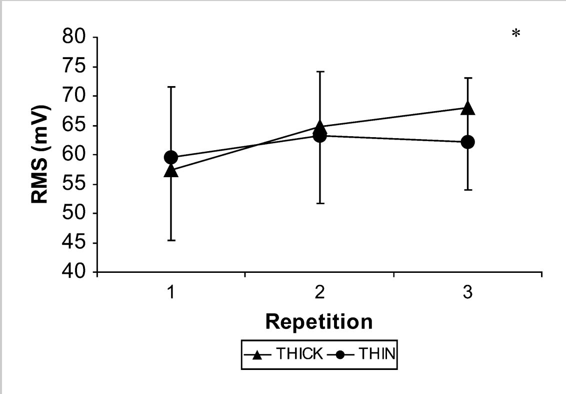

Figure 6. Root mean square for the 2 bars in the pectoralis major at angle 2. $^*p < 0.05$ versus repetition 1; main effect of repetition.

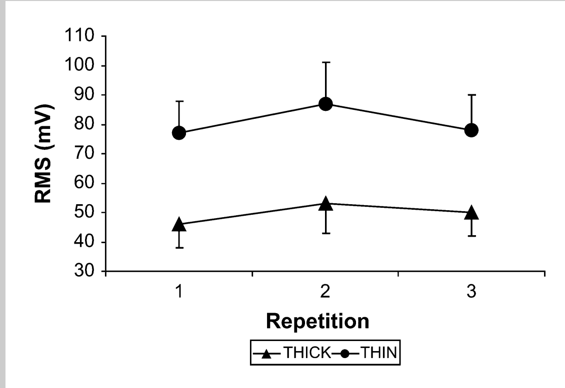

Figure 8. Root mean square for the 2 bars in the forearm muscles at angle 2. $^*p < 0.05$ vs. THICK; main effect of bar.

repetitions for a designated bar and joint angle were completed, the subjects rested for 15 minutes to ensure adequate muscle recovery before participating in the bar and joint angle testing phase. The maximal force generated by each bar at each joint angle was recorded as the subject's MVC in foot-pounds.

Day 2. The subjects returned to the laboratory 1 week later to complete the final day of testing. Upon reporting to the laboratory, subjects were positioned on the dynamometer as previously described. Electromyography electrodes were then placed on the muscle belly of the pectoralis major and the forearm flexor region (flexor digitorum superficialis and flexor digitorum profundus) on the dominant side of the body. The guidelines for the electrode placement were based on the work of previous investigators (2,14). The electrodes were connected to a Noraxon EMG system using Myoresearch software (Scottsdale, AZ). Subjects then performed 1 set of 3 isometric contractions with their dominant arm at both joint angles using the THIN bar and THICK bar. A randomized selection process determined the order in which the subjects used each bar and joint angle during this testing phase. The intensity of each contraction was 80% of the subject's MVC for each bar and joint angle, and it was maintained by having the subject aim for a goal bar on the Biodex computer screen. The 80% range was used to ensure that maximal motor unit recruitment could be obtained (11–13). Each subject was asked to maintain each contraction for 10 seconds within the goal bar to ensure sufficient electromyographic recordings. A 30-second rest interval was observed between each repetition and a 4-minute rest interval was observed between each joint angle phase to ensure adequate recovery. Electromyographic recordings were collected and recorded at a sampling rate of 1000 Hz throughout this testing day.

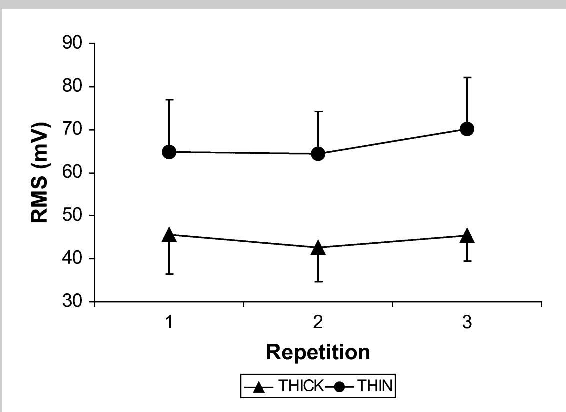

Figure 7. Root mean square for the 2 bars in the forearm muscles at angle 1. $^*p < 0.05$ vs. THICK; main effect of bar.

Data Analysis

The first 3 seconds of each contraction were omitted from analysis to allow the subjects to stabilize the contraction level and allow for stabilization of the electromyographic signal, which was consistent with previous methodology (8). The RMS was calculated for electromyographic activity during a 0.5-second window at seconds 3, 6, and 9 of each repetition. These values were averaged and reported as the mean RMS for each repetition.

Statistical Analyses

Statistical analyses were performed with Statistica 6.0 (Tulsa, OK). The MVC was analyzed using a 2 (bar type) $\times$ 2 (joint angle) repeated-measures analysis of variance for each muscle group. The RMS was analyzed using a 2 (bar type) $\times$ 3 (repetition) repeated-measures analysis of variance for each muscle group at each joint angle. When significance was found, Tukey's post hoc test was used to further examine where differences occur. A significance level of ≥ 0.05 was used for all tests. Data are reported as mean $\pm$ *SE*.

Results

The results for the MVCs are shown in Figure 4. Although there was no difference in MVC between bars, there was a main effect of angle ($p < 0.01$) such that angle 2 produced a higher MVC for both bars. For the pectoralis major, there was a main effect of bar on the RMS at angle 1 ($p < 0.05$) such that there was greater electromyographic activity with the THIN bar compared to the THICK bar (Figure 5). Regarding the pectoralis major at angle 2, there was a main effect of repetition, with post hoc analysis revealing that RMS during repetition 3 was greater than RMS during repetition 1 ($p < 0.05$; Figure 6). Regarding the forearm muscles, there was a main effect of bar at angle 1 such that electromyographic activity, reflected by the RMS, was greater with the THIN bar ($p < 0.05$; Figure 7). A similar main effect was found in the forearm muscles at angle 2 such that there was greater electromyographic activity with the THIN bar ($p < 0.01$; Figure 8).

Discussion

The primary finding of our study is that bar diameter can influence neuromuscular activation during an isometric unilateral bench press exercise. Although we did not find any significant differences in muscular strength between bars, the THIN bar elicited greater electromyographic activity when performing high-intensity isometric contractions. Thus, our data suggest that a standard Olympic bar diameter is better for eliciting neuromuscular activation, particularly in the forearm muscle group, compared to a greater diameter bar. To the authors' knowledge, this is the first study to specifically examine the influence of bar diameter on neuromuscular activation during a major upper body exercise.

One of the more recent alternatives to the traditional Olympic weightlifting bar is the fat bar, which has become widely available on the strength training market. These bars have the same circular shape as traditional Olympic lifting bars but have a greater circumference. Several strength and conditioning specialists are advocating the use of the fat bar and claim that it can significantly improve muscular strength, especially in the forearm muscle group (4). However, there is limited scientific evidence to support these claims. Therefore, this study examined the influence of bar size on neuromuscular activation and strength of muscles recruited during the bench press exercise.

Using a unilateral isometric bench press exercise, we measured neuromuscular activation and strength using a THIN bar (28-mm (1.1-inch) diameter) and a THICK bar (51-mm (2-inch) diameter), which reflect the grips of a traditional Olympic bar and a fat bar, respectively. Isometric strength was measured using both bars at 2 different shoulder joint angles to investigate these indices throughout the normal range of motion of the standard bench press exercise. Furthermore, neuromuscular activation, quantified by the RMS of electromyographic activity, was assessed during 3 repetitions at 80% of subjects' MVC using both bars at the same 2 joint angles in order to examine this variable during high-intensity muscle contractions.

There were no differences in isometric strength between bars at either of the joint angles examined. However, MVC was greater with both bars when contractions were performed at angle 2. This finding is consistent with the strength curve of the bench press exercise (7). Whereas angle 1 falls on the beginning of this curve before maximal force production is reached, angle 2 falls closer to the middle of the curve, nearer the point of maximal force production. Our finding of no between-bar differences in strength is consistent with that of Ratamess et al. (10) who reported no difference in 1 repetition maximum in pushing-type exercises (i.e., bench press, shoulder press) between bars of different diameters. However, this group did report that thicker bars resulted in decreased strength in other pulling-type exercises (i.e., dead lift, bent-over row), suggesting that bar diameter affects pushing and pulling exercises differently. Other investigators have shown that the diameter of a grip handle can significantly influence force production of the muscles used in gripping (3,9). Since the tendons of the flexor digitorum superficialis and profundus muscles insert into digits 2 through 5, changes in bar diameter alter the overlap of the actin and myosin filaments. According to the length-tension relationship, changes in sarcomere length will alter cross-bridge attachments and thus the capacity to produce force. This explains the findings of Petrofsky et al. (9) and Blackwell et al. (3) who both found that maximal force production was achieved with a mid-sized bar diameter. Our inability to see significant bar differences in force production may also be partly attributed to the fact that we assessed force production in an exercise that primarily targets the chest musculature and not the forearm muscles. Although bar diameter may significantly alter the interaction of the myofilaments in the forearm, it is likely that it minimally effects the pectoralis major.

With regards to neuromuscular activation of the forearm muscles, we report greater electromyographic activity when using the THIN bar. This finding was consistent for both joint angles examined. This finding suggests a greater degree of neural activation in the forearm muscles when performing the exercise with the THIN bar compared to the THICK bar. We found similar results in the pectoralis major muscle at angle 1, suggesting a greater degree of neuromuscular activation using the THIN bar. However, bar differences were not present in this muscle at angle 2.

Our electromyographic findings contradict some of the anecdotal claims of fat bar proponents. Strength coaches who advocate the use of thicker lifting bars have claimed that these bars keep the muscles of the forearm continuously activated (4). On the contrary, we found the opposite in our study. Our findings suggest that a standard Olympic bar is superior to a larger diameter fat bar when the goal is to maximally stimulate motor units, particularly within the forearm region, during high-intensity repetitions of an isometric bench press exercise. Our findings are in contrast to those of Grant et al. (6) who reported that the RMS of electromyographic activity increased as the diameter of the handgrip increased. However, it should be noted that the smallest handgrip of Grant et al. was ~43 mm in diameter, whereas our THIN bar was 28 mm. Thus, it is difficult to directly compare our results to theirs and it is possible that a threshold bar diameter exists, such that bars that are below a certain size affect neuromuscular activation by altering the mechanical advantage. Although this study design did not allow for elucidation of a physiological mechanism, an elevated grip force exerted while using the THIN bar could partly explain our findings. However, confirmation of this hypothesis would require a future study using an instrumented bar with the capacity to measure handgrip force production.

There are a few limitations to this study that warrant discussion. First of all, these findings are specific to isometric contractions, and we are uncertain whether similar results would be found during dynamic movements. This is an important concept in that many strength training exercises performed in athletes are dynamic in nature. However, the difficulty of analyzing electromyographic recordings from dynamic movements due to electrical artifact warranted our use of isometric exercise in order to obtain useful electromyographic data. Additionally, these findings are specific to the pectoralis major and forearm muscle groups during the unilateral bench press exercise. Thus, in light of the work of Ratamess et al. (10), it is possible that our neuromuscular activation findings may be different in other exercises in which grip may be more of a limiting factor (i.e., pulling-type movements). Future studies should investigate whether these findings hold true in other muscle groups or other types of movements (e.g., single joint movements, pulling movements). Also, hand size has been reported to be related to mechanical efficiency when performing gripping tasks (6). Unfortunately, we did not measure the hand size/grip diameters of our subjects, and it is not known whether this factor significantly affected our results. However, our population was very homogeneous in their anthropometric characteristics, leading us to believe that this was not a significant factor. Finally, this study was conducted in a group of well-trained men who have had extensive experience in strength training. Therefore, we are unsure whether these findings are generalizable to other, less trained populations.

Practical Applications

In conclusion, our data do not support the idea that that weightlifting bar diameter significantly alters muscular strength during an isometric bench press exercise. Subjects in our study were not able to generate any more or less force with our THICK bar handle, which mimics a fat bar, compared to our THIN bar, which reflects the characteristics of a traditional Olympic bar. We did, however, find that neuromuscular activation was greater when performing high-intensity muscular contractions with the THIN bar. Thus, our findings suggest that a standard Olympic bar is superior to a larger diameter fat bar when the goal is to maximally stimulate motor units, particularly within the forearm region, during high-intensity repetitions. Although we report significant differences in neuromuscular activation between THICK and THIN bars, it is important to stress that these findings are specific to the bench press, a pushing exercise. In light of the previously noted possibility that pushing and pulling exercises may differ with regards to how they are affected by bar diameter, further investigation of neuromuscular activation is warranted in pulling-type resistance training exercises. These results may be applicable for strength coaches and those participating in resistance training programs searching for ways to maximize neuromuscular activation.

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