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Effects of Increased Eccentric Loading On Bench Press 1RM

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ABSTRACT

The purpose of this study was to measure the effects of additional eccentric loading on subsequent concentric strength. Eight subjects with some experience in weight training volunteered to perform maximal attempts in the barbell bench press using detaching hooks that allowed them to lower 105% of their concentric 1 repetition maximum (RM) and raise 100%. The detaching hooks allowed attachment of extra weight to the bar and would release from the bar at the bottom of the lift, reducing the weight lifted during the concentric phase of the lift. After determining their 1RM for the bench press, the subjects attempted to increase their performance by using a heavier eccentric load with the detaching hooks. All 8 subjects who completed the study increased their 1RMs by 5 to 15 pounds. The use of additional eccentric loading significantly ($p = 0.008$) increased the weight that could be lifted on the subsequent concentric phase and therefore 1RM performance. This phenomenon was a result of the enhancement of stretch-shortening cycle performance by the increased eccentric load. Athletes who are interested in developing 1RM strength in the bench press may benefit from the use of additional eccentric loading.

Key Words: stretch-shortening cycle, strength, training, power lifting

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Introduction

Although many strength and power athletes train incessantly to increase their concentric 1 repetition maximums (RM), the benefits of additional eccentric loading may be overlooked. In most human activities, a movement in the opposite direction or an eccentric motion precedes a movement towards the intended direction. This combination of eccentric and concentric actions is termed a stretch-shortening cycle (SSC) and it is well established that performance is enhanced by the prior countermovement. For example, several investigations comparing purely concentric squat jumps to countermovement jumps have shown that greater force, work, and power are produced for a given concentric contraction when it immediately follows an eccentric stretch of the same muscle (14). It has also been observed that drop jumps increase vertical jump mechanical power output even more than just countermovement jumps (1, 14). A drop jump involves dropping down from a specified height and continuing into a maximal jump upon landing. The improvement in jumping is due to the increased loading of the musculotendinous unit during the countermovement or eccentric phase of the movement (3). Similarly, Wilson found a positive relation between eccentric bar acceleration and concentric lift performance in elite bench-press athletes and determined an optimal eccentric load on the basis of the bar acceleration for bench-press performance (23). One more variable that could be affected with additional eccentric load on the bench press as compared with the drop jump is the static prestretch, which is stretching of the musculotendenous unit at the top of the lift before any movement of the bar occurs. How this contributes to musculotendinous stretch and preload at the bottom of the lift is not known and requires investigation.

The bench press is an ideal exercise to investigate the effects of increased eccentric loading. During a free-weight bench press with heavy loads, a sticking point occurs relatively early in the concentric phase (16, 22). Because the benefits of the increased eccentric loading should be most prevalent in the early parts of the concentric phase (18), this potentiation should assist the lifter in pushing a greater mass through the sticking region. It is hypothesized that an increased eccentric load will increase the bench press 1RM. The purpose of this study was to investigate the immediate effects of an increased eccentric load on bench press 1RM.

Methods

Experimental Approach

For this eccentric load investigation, a randomized, balanced, within-group research design was used. We hypothesized that additional eccentric loading will acutely increase bench press 1RM. Subjects were randomly assigned to 1 of 2 experimental groups. One group of subjects performed bench press 1RM testing with additional eccentric loading and 1 group without. After 5 days of rest, the subject groups then crossed over and completed the other testing condition. Concentric bench press 1RM means were calculated and compared within subjects for the with and without additional eccentric load conditions.

Subjects

Eight of 10 moderately trained men (mean height 177.8 cm; mean age 23.9 years; mean body mass 80.5 kg) completed this investigation. The institutional review board committee of the university approved the investigation. Subjects were fully informed of the purpose and risks of participating in this investigation and signed informed consent documents before testing.

Preliminary Testing

Ten subjects completed a preliminary control study to determine if there was a change in 1RM strength over a 3-day period for the barbell bench press. One RM strength was determined according to the following methods (15). Subjects were required to perform a warm-up of 10 repetitions at 50% of 1RM, 5 repetitions at 70% of 1RM, 3 repetitions at 80% of 1RM, and 1 repetition at 90% of 1RM, followed by 3 attempts to determine their actual 1RM. The following 2 days the subjects completed that same warm-up protocol and were asked to duplicate their previous day's 1RM. After this attempt the subjects tried to increase their 1RMs on 2 consecutive attempts. All subjects were given 3 minutes of rest between sets. There were no significant changes in the 1RMs over the 3 consecutive days.

Testing Procedures

Eight of the same 10 subjects that participated in preliminary testing completed the following test procedures. On day 1 and day 2, which were separated by 2 days of rest, subjects were required to perform the same 1RM protocol outlined above. After the 1RM protocol, each subject performed a familiarization protocol using the weight-release devices. After each of these 1RM testing sessions, the bar weight was decreased to 50% of 1RM with 5% of that weight placed on the weight-release devices. Each subject then performed 5 single repetition lifts to become comfortable with the device.

On the third day of testing, which took place 5 days later, the subjects followed the same warm-up and 1RM testing protocol with the empty weight-release devices on the bar. A randomized group of half of the subjects then performed their 1RM with the use of the hooks and an additional eccentric load equal to 5% of their concentric 1RM. That is, the subjects lowered 105% of their 1RM and raised 100%. After this attempt, the subjects were allowed to perform 2 more attempts with increases in 1RM bar weight of 2.27, 4.55, and 6.82 kg, respectively, if they were successful with previous attempts. The weight on the hooks was increased proportionally so that the weight on the hooks remained 5% of the new weight on the bar. On day 4 of the testing, which took place 5 days after day 3, the randomized groups crossed over and the four remaining subjects performed their 1RM testing with the additional eccentric load. The other group repeated 1RM testing with empty weight-release devices on the bar.

Equipment

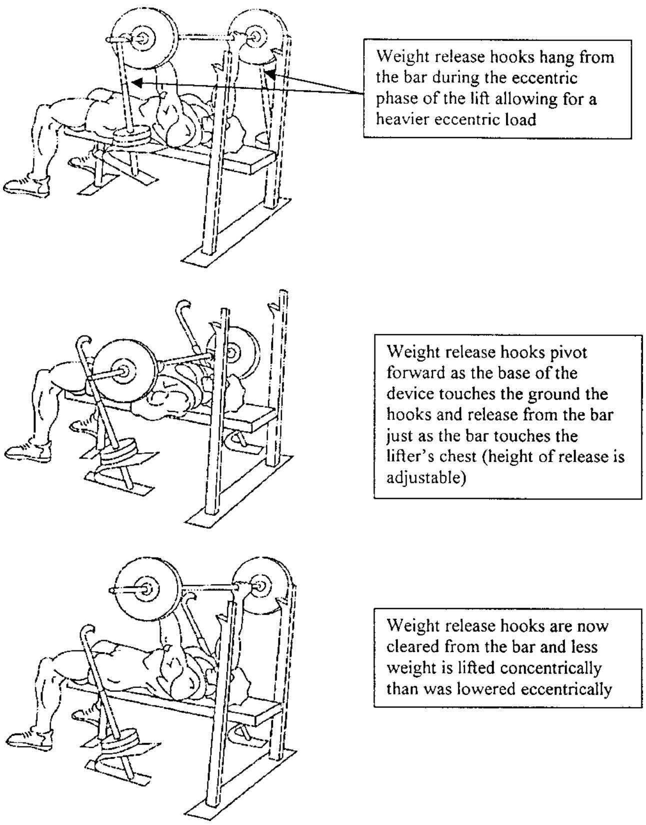
The weight-release devices used in this study (Power Recruit Inc., Hautzdale, PA) hang from the barbell and allow attachment of extra weight to the bar. The hooks are designed to release from the bar at the bottom of the lift, reducing the weight lifted during the concentric phase of the lift (see Figure 1). The adjustable hooks were set at individual heights so that they would detach at the bottom of the motion when the bar made contact with the chest of each subject. The base of the hanging hook device is angled so that when the base touches the ground the hook pivots forward and detaches from the bar.

Statistical Analyses

Means and standard deviations were computed for the conditions with and without additional eccentric load. A dependent, two-tailed t-test was applied to identify whether the means were significantly different. The criterion for statistical significance was set at an α of $p \leq 0.05$. Correlation coefficients using the Pearson method were calculated to assess the reliability of the 1RM data ($R^2 = 0.95$).

Results

The results demonstrated that additional eccentric loading is beneficial in producing acute increases in



Weight release hooks hang from the bar during the eccentric phase of the lift allowing for a heavier eccentric load

Weight release hooks pivot forward as the base of the device touches the ground the hooks and release from the bar just as the bar touches the lifter's chest (height of release is adjustable)

Weight release hooks are now cleared from the bar and less weight is lifted concentrically than was lowered eccentrically

Figure 1. Patented weight-release devices provide additional eccentric loading and are released at the bottom of the bench press before the concentric phase.

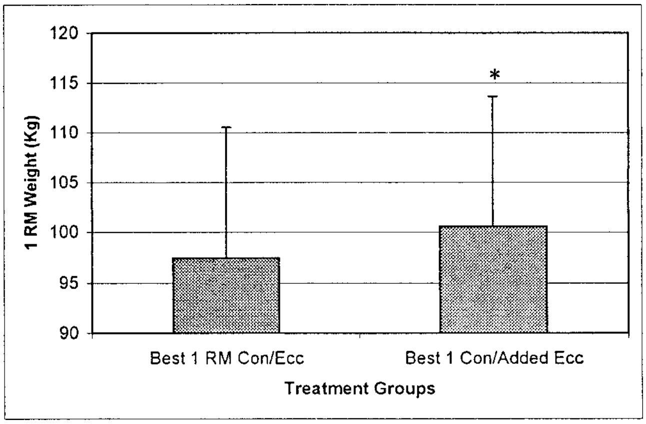


Figure 2. Mean bench-press 1 repetition maximum under normal eccentric/normal concentric and added eccentic/normal concentric conditions. *, Added eccentric condition significantly greater than normal eccentric condition (p = 0.008).

bench press 1RMs. A comparison between 1RMs on the bench press with and without added eccentric loads appears in Figure 2. Significantly (p = 0.008) higher concentric strength scores were demonstrated when the added eccentric loads were applied. The mean bench press 1RM increased from 97.44 kg for the normal eccentric condition to 100.57 kg for the increased eccentric load condition.

Discussion

From the results of this study we observed a significant increase in bench-press 1RM due to increased eccentric loading. Similar findings are noted by several studies comparing countermovement jumps with drop jumps (1, 14). There are several possible explanations for the increase in concentric contractile force due to increased eccentric loading, and an extensive review is provided by Walshe et al. (22). Prior research seems to identify 4 main categories of possible explanation for this phenomenon: increases in neural stimulation, recovery of stored elastic energy, contractile machinery alterations, and increased preload.

One possible explanation for the increase in concentric force is an increase in neural stimulation of the muscle due to the greater stretch of the intrafusal muscle fibers (muscle spindles) during the increased eccentric load. Intrafusal fibers then stimulate their specialized γ motor neurons, which would signal the brain to fire more α motor neurons or increase the rate of firing, thus increasing the force of contraction in the extrafusal muscle fibers (6). Essentially, you are tricking your brain into neurologically preparing for a heavier concentric contraction by applying a heavier-loaded eccentric contraction. It is unlikely, however, that this increased neural stimulation is the sole cause for the increase in concentric force. Studies have shown only a slight increase in electromyographic activity during increased eccentric loads (3).

Another possible explanation for the increase in concentric 1RM due to additional eccentric loading may be found in the elastic aspect of the muscle. Similar to the action of a stretched elastic band, the recoil of the stretched parallel and series musculotendinous complex contributes to force in the opposite direction (4, 7, 11). The parallel elastic component includes the tension of the muscle fasciae, connective tissue, and sarcolemma (20). The series elastic component has an active and a passive component. The active component is dependent on muscle tension and can store up to 4.7 J/kg. The passive portion is the tendon collagen, which can store up to 9,000 J/kg. (12, 17, 21).

Elastic energy can be affected by time between eccentric and concentric contractions (5), magnitude of stretch (7), and velocity of stretch (19). These variables were not specifically measured in this study, but the increased eccentric load may have affected 1, 2, or all 3 in some fashion. In other words, a greater static (i.e., at the start of the lift) and dynamic eccentric force may increase the storage of elastic energy in the muscle fibers and tendons—contributing to a greater concentric contraction force.

There is a considerable interaction between the contractile mechanics and the tendinous recoil of the musculotendinous unit. Because of the elastic nature of tendon, the additional force present at the start of the concentric phase following the stretch or eccentric phase results in relatively greater tendinous extension with less myofibrillar displacement (9). Therefore, in SSC movements there is the potential for the muscle fibers to be displaced less and thus be operating closer to an optimal length. Using the same reasoning, it is also feasible that the recoil of the tendinous structure would allow the velocity of shortening of the contractile element to proceed more slowly with a corresponding enhancement to force production because of the force-velocity characteristics of muscle contraction. The increased eccentric load during the bench press performed with the hooks in this study may have increased this effect and thus further contributed to a greater weight being lifted.

Several researchers (2, 22) have suggested that the greatest contribution to the enhancement of concentric performance by prior eccentric movement is due to the preload. The countermovement allows the agonist muscles to build up active state and force before shortening and allows the subject to attain greater joint moments at the start of the upward movement. As the sticking region for the bench press during a 1RM occurs relatively early in the movement (24), the greater forces exerted against the bar and subsequently an increase in impulse ($F \times t$), and thus acceleration of the bar upward, may allow the subject to lift a greater load through this region and thus measured 1RM is higher. Several possible mechanisms have been discussed here that may be causing acute improvement in concentric strength. Further study is required to validate and quantify the underlying mechanisms.

A second important aspect to this study is the possible benefits in terms of training effectiveness that may be derived from performing lifts with a heavy eccentric load. It has been well documented that the neuromuscular system can develop considerably higher tension during eccentric contractions (8, 10). Therefore during weight training the eccentric phase may not be optimally loaded because the weight on the bar is limited to that that can be lifted through the sticking region of the concentric phase. Maximal eccentric training results in greater neural adaptation and muscle hypertrophy than concentric training (13). Although further research is required, the additional load on the eccentric phase provided by the weight-release hooks may enhance strength development.

Practical Applications

The prospects of heavy eccentric loading are exciting for strength and power athletes. The data obtained from this investigation indicate that athletes will be able to acutely increase their concentric bench press 1RM simply by applying additional load on the eccentric phase of the lift. Therefore, it is also possible that an enhanced training effect could be realized if increased eccentric loading is implemented as part of a strength-training program. Eccentric and concentric loads will be acutely increased, increasing the intensity and total volume of any workout, possibly causing a greater training effect. A longitudinal training study is required to investigate the possibility of a training effect due to increased eccentric loading.

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