# Improved Functional Power Over a 5-Week Period: Comparison of Combined Weight Training to Flexible Barbell Training

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## Abstract

Caterisano, A, Hutchison, R, Parker, C, James, S, and Opskar, S. Improved functional power over a 5-week period: Comparison of combined weight training with flexible barbell training. *J Strength Cond Res* 32(8): 2109–2115, 2018—Previous studies demonstrated increased power development with various resistance-training modes over short training periods of 4–7 weeks through neuromuscular adaptations. The purpose of this study was to compare 2 different power-training regimens over a 5-week period: combined weight training program (CT) using speed-lifts and plyometrics vs. flexible barbell (FB) training. College football players ($n = 28$) were randomly assigned to either FB or CT training groups. The CT group followed a combined weight training program using 45–65% of 1 repetition maximum, and the FB group used an FB with a fixed mass of 56.82 kg for all lifts. Both groups performed similar lifts 4 days per week in a split routine, alternating muscle groups. Subjects were tested before and after the training period by the vertical jump (VJ), long jump, medicine ball (MB) throw, and Margaria-Kalamen stair power test. Pre- to post-tests, both groups experienced significant increases in VJ (CT: 57.9 ± 8.9 to 64.5 ± 7.9 cm, FB: 68.1 ± 6.9 to 74.9 ± 6.6 cm) and MB (CT: 513.3 ± 69.3 to 594.9 ± 78.2 cm, FB: 510.0 ± 41.4 to 613.9 ± 52.6 cm) that were not significantly different between training modes. Long jump improved significantly only in FB (248.4 ± 23.1 to 254.3 ± 24.6 cm) and not in CT. The Margaria-Kalamen stair power test result improved in both groups but FB improved at a significantly higher level than CT (CT: 40.6 ± 2.3 to 44.3 ± 2.2 W, FB: 41.0 ± 1.7 to 48.8 ± 1.8 W). The results suggest that both FB and CT training improved power over a 5-week training period, but that FB training may be more effective than CT in lower-body power development.

**Key Words** football, vertical jump, Margaria-Kalamen test, training mode

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## Introduction

Researchers have focused on comparing different training modalities to find whether one type is more effective in training athletes for increased power over relatively short training periods of less than 7 weeks (1–5,9,14). Neuromuscular adaptations as a result of power and speed training have been documented in studies using training periods as short as 2 weeks (2). Of the studies reviewed, those focusing on power development had training protocols lasting 4–7 weeks in duration (3–5,9,14). A 6-week study compared sprint training with plyometric training, weightlifting, and resisted sprint training and found that all were equally effective in improving acceleration (15). Variables such as training velocity and rest intervals have also been compared for neuromuscular training effects in several studies (3,5,17). Some of these studies reported relatively equal improvements among the different modes tested (2,3,14), whereas other studies that focused on combined weight training, in which both power and strength training were combined, did show superior results compared with strength training or power training alone (1,5,9).

The flexible barbell (FB) is a relatively new mode of resistance training that has been used by several major college football programs and a few NFL teams (20). The FB is designed to provide high resistance at predetermined intervals in the lifting motion but then allows for maximum acceleration through the rest of the range of motion (ROM) of the lift. As the flexible bar flexes downward, the lifter reverses the direction of the bar with an impulse force that has been shown to be greater than the mass of the barbell (11,12). The manufacturers of the bar claim that this momentum created by moving the bar at relatively fast speeds generates forces greater than the bar load and also oscillates to provide stimulus to stabilizer muscles (tsunamibarbell.com).

Recently published research, using force plate data and electromyography, tested these claims in the laboratory setting (11,12). This study used both machine-generated movement and human movement, using the back squat exercise, to test this hypothesis. Results suggested that the flexible bar generates forces that are greater than an equally weighted steel bar, moved at the same speed, in both the machine-generated data and the human data during the back squat (11). The data also supported the hypothesis that stabilizer muscles were more highly activated in performing back squats using the flexible bar compared with an equally weighted steel bar moved at the same speed. Also, data presented at the 64th American College of Sports Medicine Annual Meeting demonstrated that the faster the FB is moved, the greater the ground reaction forces, when the bar was moved by a variable speed machine atop a force plate (12). The machine was similar to the one described in a previous study (11). The only similar studies that focus on lifting an unstable barbell did find a similar increased activation of stabilizer muscles during the bench press compared with a steel bar (13,16). However, the aforementioned research did not test the effect of moving the bar at different speeds on ground reaction force. With these recent research results and adoption by many football programs, a training study would provide critical evidence to inform athletic programs looking to increase performance by incorporating such a device.

Combined weight training is a popular approach to resistance training program design and is based on training regimens that combine strength and power training modes (1,5,9,19). It is very similar to conjugate training that also intertwines strength and power exercises and has been shown to be superior compared with high force programs (19). Combined weight training programs intermix plyometric exercises with submaximal weightlifting, often incorporating chain lifts, board presses, and Olympic lifts and are very popular among college strength and conditioning coaches (1,9,19).

The purpose of this study was to compare an FB power training program to a combined weight training program to determine the efficacy of each in developing upper and lower-body power in athletes over a 5-week training period.

## Methods

### Experimental Approach to the Problem

The recently published study by Hutchison and Caterisano described the physical characteristics of the FB and the level of muscle activation, compared with a steel Olympic barbell (11,12). The results suggested that the ground reaction forces generated by the momentum created by moving the flexible bar rapidly were greater than that of a similarly weighted Olympic barbell. The study also found that core muscle and prime mover muscles used during the back squat were significantly more activated when using the FB than those of an equally weighted steel bar when both were lifted at the same speed. Previous research on bench pressing unstable training loads generated by a flexible bar, which showed higher muscle activation compared with a similar training load using a more stable steel barbell, supports the latter findings (13,16).

Given that the physical characteristics of the FB have been established, our question was whether this mode of resistance training would yield greater neuromuscular adaptations with respect to muscle power compared with a more traditional speed training program using a steel Olympic barbell. We chose a combined weight training program to represent the traditional training regimen (1,5,9). This program uses Olympic barbell lifts such as power cleans, squats, and various presses, augmented with chains, while keeping the resistance levels between 45 and 65% of the athlete's 1 repetition maximum (1RM). It also used lower- and upper-body plyometrics with box jumps and a 14-pound 2-handed medicine ball (MB) throw, and partial lifts such as board presses to develop power. Considering that combined weight training was shown to be more effective in developing power in athletes than do strength-only and power-only protocols, we believed that this approach represented many college-level strength and conditioning programs (1,5,9).

NCAA Division I (FCS) freshman football players who were scheduled to take a red-shirt year were recruited as subjects. None of the subjects had used the FB, yet all had typical training histories that one might expect of Division I football athletes. We allowed for a 1-week familiarization period during which athletes rehearsed the tests and learned the lifting techniques of their respective training programs. All tests were performed in 1 day with the test order randomized to prevent order effects and with sufficient time between tests to allow for full recovery.

### Subjects

NCAA Division I college football players ($n = 28$ males; age $= 18.8 \pm 0.4$ years; mass $= 102.8 \pm 5.3$ kg; mean $\pm$ *SD*) volunteered as subjects and were randomly assigned to 1 of 2 experimental groups. No subjects under 18 were recruited. The project was approved by the Furman University Internal Review Board on Human Subjects, and all subjects read an informed consent form, which each subject signed after being informed of the procedural risks. Subjects were tested during the week preceding the 5-week training period and immediately after the training period at the same time of day and in the same ambient environment.

All subjects were experienced weight lifters but none had previously engaged in either type of experimental training protocols. Group CT engaged the combined weight training program described below, and group FB performed similar training exercises with a flexible Tsunami Bar (Tsunami Bar, L.L.C., West Columbia, SC). Workouts were performed 4 days per week in a split routine in which upper body lifts were performed twice per week and lower body twice per week as part of a summer workout regimen for varsity football. Both groups performed all other training associated with summer camp (i.e., drills and conditioning) equally over the 5-week training period.

**Procedures**

The tests selected to measure power have been shown to be valid and reliable tests for assessing power (6–8,10,15). Subjects practiced all tests during familiarization trials, and all engaged in a group warm-up before testing. Tests were conducted in a climate-controlled, single testing session, with tests randomized to prevent order effects. Those administering the tests were unaware of which training group was assigned to each subject. Subjects were measured for height and weight and then tested in a random order as described below.

*Margaria-Kalamen Stair Test.* Subjects were instructed to take a 6-meter run-up to a flight of stairs, upon which the third, sixth, and ninth step were marked with reflective tape. Each subject was told to use only the marked steps to climb the stairs as quickly as possible. Four testers used stopwatches, which were started when the subject's foot hit the third step and stopped when their foot hit the ninth step. The testers were positioned so that the steps were clearly visible, off to the side at ground level. Times were compared and accepted only if all 4 stopwatches were within 0.02 seconds. Failure to meet those requirements resulted in a retest. The best of 3 acceptable time trials was recorded.

Power scores were calculated in Watts by multiplying the subject's body weight in kilograms times 1.03 m, which was the distance between the third stair and the ninth stair. This product was then divided by the best of 3 recorded times to determine $kg \cdot m^{-1} \cdot min^{-1}$, which were then converted to Watts (10).

*Standing Long Jump.* Subjects stood stationary on a line of a gymnasium floor, and using upper-body countermotions, jumped as far as they could. The distance was measured in centimeters from the line to the subject's closest body part to the take-off line. The best of 3 trials was recorded (15).

*Standing Vertical Jump.* Subjects stood under a Vertec™ apparatus extending both arms up. The bottom vane on the Vertec was aligned with the subject's dominant hand fingertips. From a stationary position, the subject used upper-body countermotions and jumped as high as possible, slapping the highest vanes he could reach with the dominant hand. The vertical jump (VJ) distance in centimeters was measured

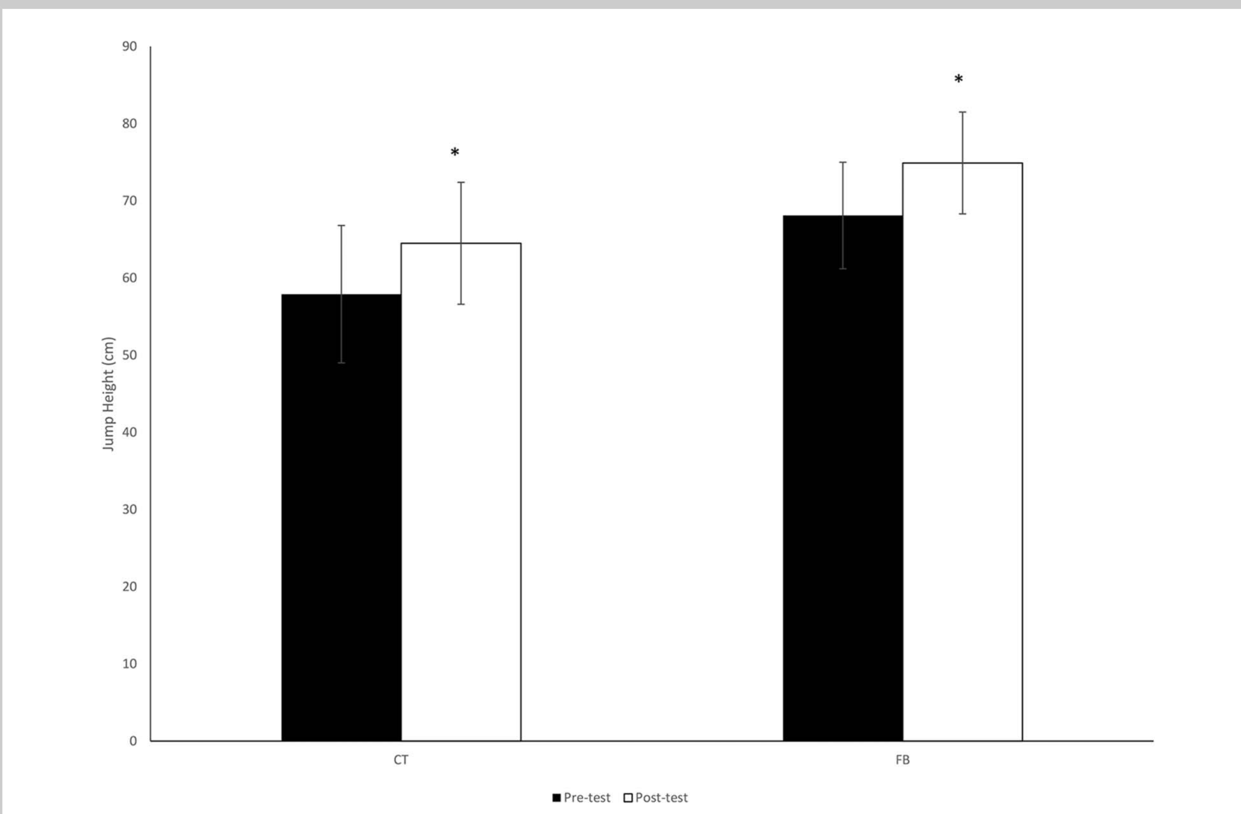


**Figure 1.** Vertical jump pretest and posttest results showing significant differences (*$p \leq 0.05$). FB = flexible barbell.

from the bottom vane to the highest vane displaced with the dominant hand. The best of 3 trials was recorded (15).

*Medicine Ball Throw.* A flat bench was placed along a block wall, and a tape measure was placed on the floor perpendicular to the bench. Each subject was instructed to sit on the bench with his back against the wall and throw a 5-kg Medicine ball using 2 hands, simulating a basketball chest pass. A throw was disqualified if the subject's back moved off the wall or the subject used only one hand. The best throw of 3 trials was measured in centimeters (6,7).

*Combined Weight Training Workouts.* All subjects were tested for 1RM 1 week before the training session. Subjects worked out 4 days per week in a 2-day split routine (upper-body lifts twice per week and lower-body lifts twice per week). The exercises and their relative intensities and volume were as follows:

*Lower Body.*

Box jumps: 3 sets of 5 repetitions–week 1–2, 50-cm box; week 3–4, 75-cm box; and week 5, 100-cm box

Front squat: 50–65% of 1RM 4 sets (reps = 8 at 50%; 5 at 55%; 3 at 60%; 3 at 65%)

Back squat: 50–65% of 1RM 4 sets (reps = 8 at 50%; 5 at 55%; 3 at 60%; 3 at 65%)

Power snatch: 62 kg 3 sets of 3 reps.

Power cleans: 93 kg 4 sets (reps = 5/4/3/3).

*Upper Body.*

Chain bench press: 45–60% of 1RM 3 sets of 3 reps for speed (each set increased by 5% 1RM using 18-kg chains)

Board bench press: 4, 3, and 2 boards 84 kg. Three sets of 3. Boards were placed on each subject's chest to limit the full ROM of the bench press. Each board was 2 inches thick. The first set reduced the full ROM by 8 inches using 110% of the 1RM, followed by a 6-inch reduction using 107% of the 1RM and finally by a 4-inch reduction using 105% of the 1RM.

Medicine ball throws: A 6.4-kg Medicine ball was thrown with a 2-handed chest pass motion while the athlete sat on a bench against the wall. Two sets of 12 reps.

Athletes were instructed to perform each repetition as fast as they could to mirror FB lifts in all lifts.

*Flexible Barbell Training Workouts.* The resistance for the flexible barbell (West Columbia, SC) training group was the

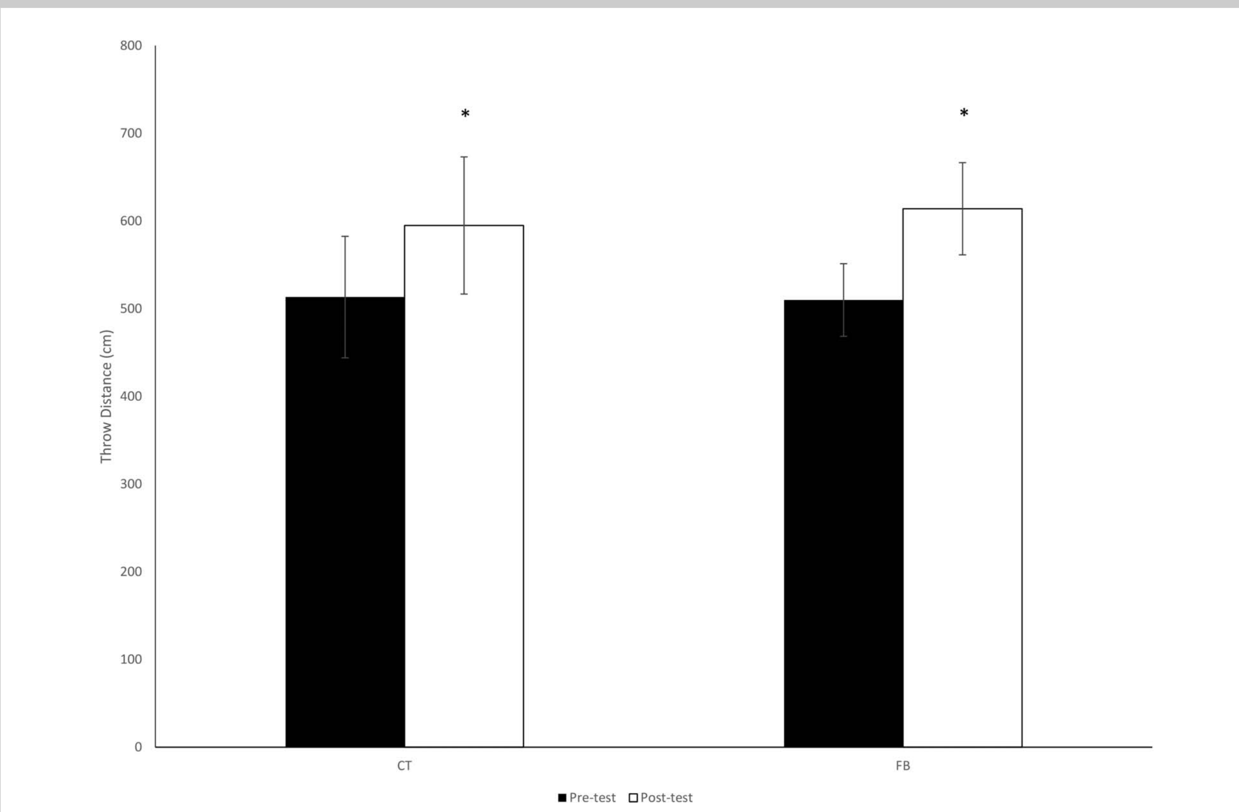


**Figure 2.** Medicine ball pretest and posttest results showing significant differences (*$p \leq 0.05$). FB = flexible barbell.

same for all subjects. The manufacturer recommends this for group training because the resistance is dependent on how fast the athlete moves the bar (20). As the speed of the bar increases, the momentum of the weights increases the amount of reversal force needed to change the direction of the barbell (11,12). Subjects were instructed to move the FB as fast as possible, through a full ROM. This group also performed a similar 4-day split routine as the CT group.

*Lower Body.*

Flexible bar squats: 56.82 kg. Four sets of 9 reps with the first 3 repetitions performed flat-footed (heels), the next 3 repetitions performed with the athlete's weight shifted to his toes, and the last 3 repetitions starting flat-footed but ending with a jump.

Flexible bar cleans and press: 56.82 kg. Four sets of 3 reps

*Upper Body.*

Flexible bar bench press: 56.82 kg. Eight sets of 8 reps

Flexible bar jammers: 56.82 kg. Five sets of 5 reps. Jammers are performed with an FB suspended in a power rack by nylon straps over the head of the athlete. The athlete reaches up and grabs the barbell, and uses an explosive jumping action forward, while extending the barbell upward. The motion is similar to a push-press except that the athlete moves forward.

### Statistical Analyses

Statistical analyses were performed with SPSS version 17.0 (SPSS, Inc., Chicago IL, USA). Data were tested and indicated that the sample distribution was normal (Shapiro-Wilk test for normality). Power indexes from the Margaria-Kalamen Stair test were calculated in Watts, as previously described. All data were statistically analyzed using a 2-way multivariate analysis of variance with a Tukey post hoc test. A 95% confidence interval was calculated, and statistical significance was $p \leq 0.05$.

## Results

The results are presented in the bar graphs. CT and FB showed similar improvements in VJ and MB over the 5-week training period ($p < 0.05$), but there was no difference between the 2 experimental groups (Figures 1 and 2, respectively). Although both groups improved in the Margaria-Kalamen stair power test (MPT), the FB group experienced significantly greater improvements compared with CT ($p = 0.02$) (Figure 3). The FB group significantly improved in long jump (LJ) ($p < 0.05$), whereas the CT group did not.

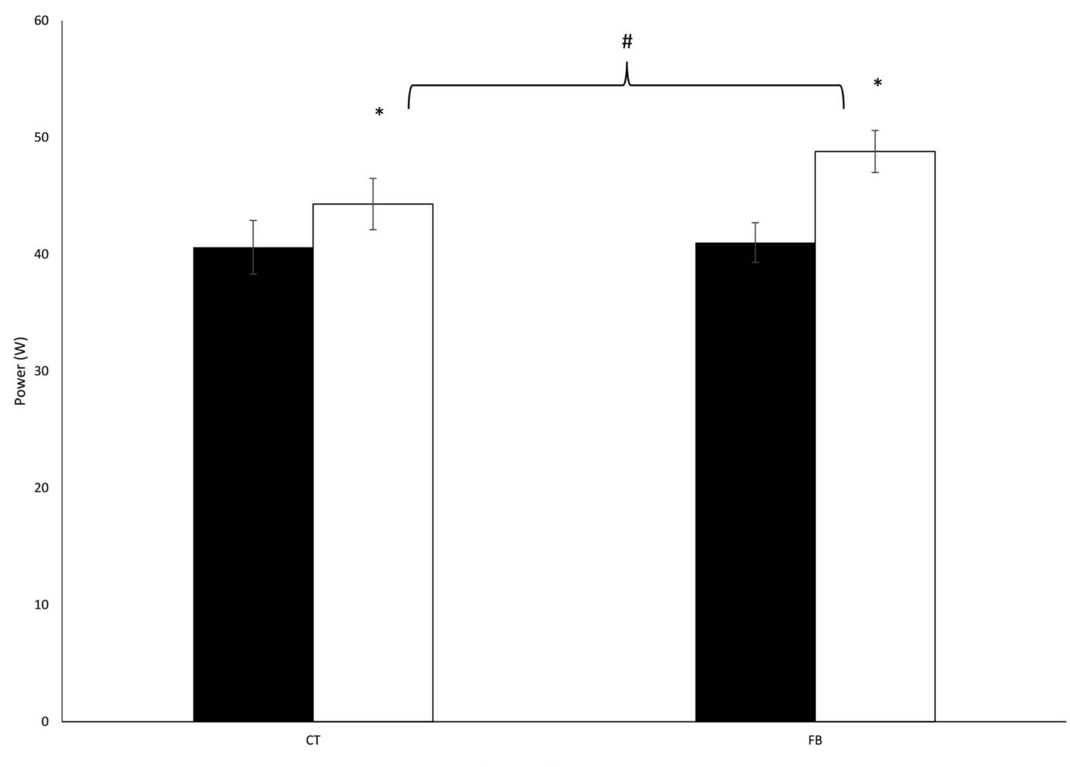


**Figure 3.** Margaria-Kalamen power pretest and posttest results showing significant differences (*$p \leq 0.05$, #$p = 0.02$). FB = flexible barbell.

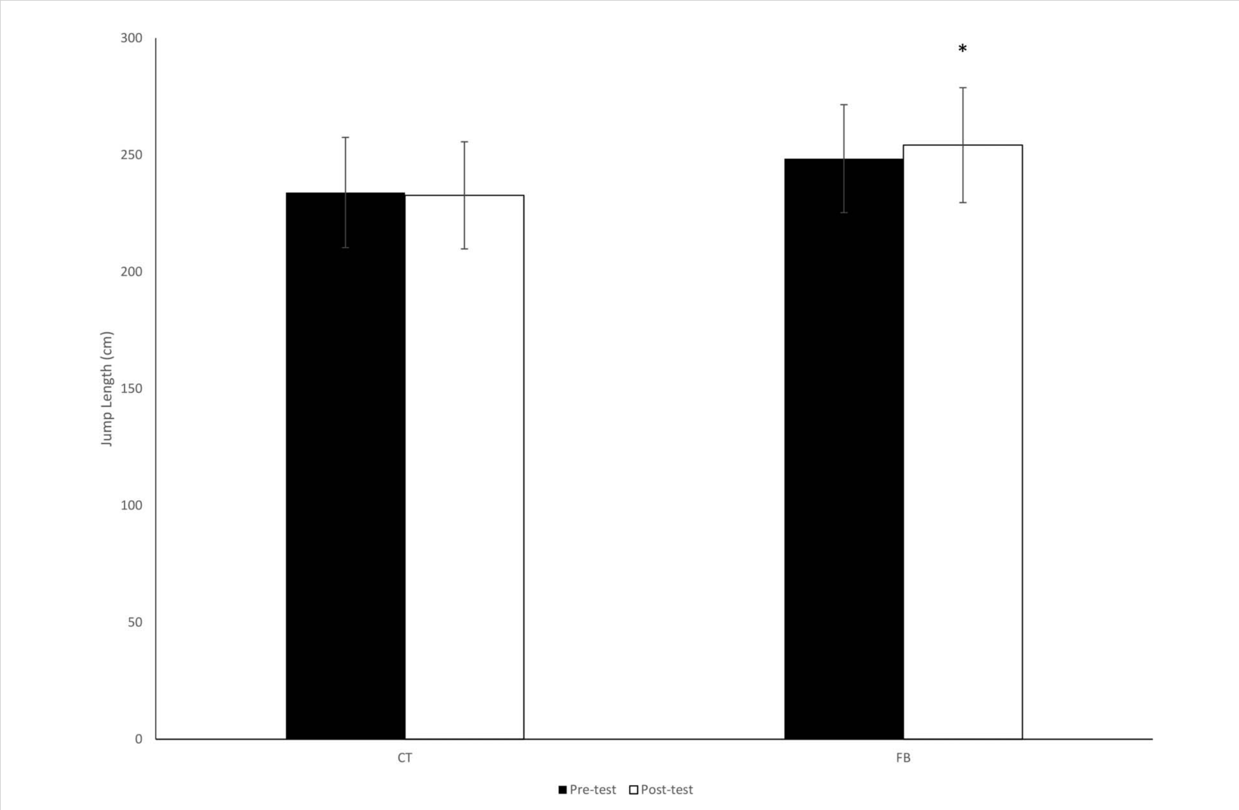


**Figure 4.** Long jump pretest and posttest results showing significant differences (*$p \leq 0.05$). FB = flexible barbell.

Pre- to post-tests, both groups experienced significant increases in VJ (CT: 57.9 ± 8.9 cm to 64.5 ± 7.9 cm, FB: 68.1 ± 6.9 cm to 74.9 ± 6.6 cm) and MB (CT: 513.3 ± 69.3 cm to 594.9 ± 78.2 cm, FB: 510.0 ± 41.4 cm to 613.9 ± 52.6 cm) that were not significantly different between training modes. Long jump improved significantly in the FB group (248.4 ± 23.6 cm to 254.3 ± 24.6 cm) and not in the CT group (233.9 ± 23.6 cm to 232.7 ± 22.9 cm) (Figure 4). The MPT improved in both groups, but the FB group improved at a significantly higher level than the CT group (CT: 40.6 ± 2.3 W to 44.3 ± 2.2 W, FB: 41.0 ± 1.7 W to 48.8 ± 1.8 W).

## Discussion

No significant difference was found between the pretests between the 2 groups in the VJ, MB, or MPT. However, a significant difference was present in the pretest in the LJ between the groups. Typically, this would be of concern if the group that had a lower pretest score saw a significant improvement that could be attributed to an initial underperformance in the pretest; but in this case, it was the group with the higher LJ score that experienced the improvement. The results of this study suggest that both forms of training (CT and FB) improved VJ and seated, 2-hand MB throw equally over the 5-week period. It is interesting to note that the CT group actually trained using an MB, whereas the FB group did not, yet both groups improved similarly.

The FB group saw significantly greater improvements in the Margaria-Kalamen Stair test and standing LJ compared with the CT group. These results are consistent with previous studies, which compared speed-specific exercises with more traditional forms of resistance and plyometric training (3,4,14,18). One reason for this, which is supported by recently published research, is that lifting an unstable weight may activate stabilizer and prime mover muscles to a greater extent than lifting a stable weight (11,13,15). Two studies found that even when the unstable resistance was a smaller percentage of the 1RM, the muscles used in the bench press were more highly activated by an unstable resistance, compared with a heavier stable weight (13,16). Another study compared an equally weighted stable resistance with an unstable resistance in the back squat and found similar results (11). The latter research also found that peak ground reaction forces were greater in an FB, and because power is based on performing work in the shortest amount of time, this factor could also contribute to better performance on the power tests used in this study. The one drawback to studying the FB training program is that it was not possible to equate the training loads of the FB to the CT. This was due to the variable nature of the FB forces, which are based on how fast the athlete moves the bar (12). During training, each subject moved the bar at different speeds depending on his strength level. Based on our results, we conclude that FB training may be a more effective way to increase neuromuscular adaptations in leg power compared with more traditional combined weight training protocols.

## Practical Applications

The results of this study suggest that for a strength coach who wishes to increase an athlete's power in preseason training, the FB may be more effective than more traditional methods. The FB programs also seem to have the advantage of eliminating the need to change weights to attain different percentages of the 1RM in each workout, as well as using different weights to accommodate different strength levels of athletes training in a group environment. With the FB, the resistance level increases with increased speed of movement so that a stronger athlete will move the bar faster and a weaker athlete will move the bar more slowly (11,12). A strength and conditioning coach training a large group of athletes with a wide range of strength levels might find this a valuable time saver by not having to change the resistance for each athlete.

What is probably of most interest to strength and conditioning coaches is simply "Does it work?" According to our data, the FB improved power in some tests to a greater extent than the combined weight training program tested. Further research testing the FB against other resistance training modes is recommended. Testing athletes over longer training periods is recommended to determine whether there are differences in hypertrophic adaptations would be of value.

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