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Functional Isometric Weight Training: Its Effects on Dynamic and Static Strength

Katie L. O'Shea and John P. O'Shea
Human Performance Laboratory
Oregon State University
Corvallis, Oregon 97331

ABSTRACT

For the athlete or weight trainer who has reached a strength plateau, finding an optimal training program that will stimulate a further strength increase can be a complex problem. The purpose of this study was to compare the effects of two squat training programs utilizing the parallel squat and a functional isometric squat on dynamic strength, static strength and power in college males. Ten subjects enrolled in an advanced power weightlifting class were divided equally into two groups—a functional isometric squat group (FIS), or a dynamic squat group (DS). The subjects trained two days per week for a total of eight weeks, which consisted of a two week pre-conditioning and technique learning period followed by a six week "periodized" functional isometric or dynamic squat training program. Changes in dynamic and static strength were measured with a 1 RM parallel squat and knee extension cable tensiometer test, respectively. Power capacity was assessed by a vertical jump test. Statistically, analysis of the data revealed a significant increase ($p < 0.01$) in dynamic strength for both groups. The FIS group, however, realized a statistically greater improvement ($p < 0.05$) than the DS group. Neither group showed changes in static strength. Both groups made a significant increase ($p < 0.05$) in power, although the DS group had a statistically greater improvement ($p < 0.01$) than the FIS group ($p < 0.05$). The results seem to indicate that functional isometric squat training is highly effective in increasing leg strength but not as effective as dynamic squat training for improving jump power.

KEY WORDS: Functional isometrics, dynamic strength, power, periodization, 1 RM.

Introduction

The concept of functional isometrics (FI) was first proposed by Hoffman (2) to optimize strength in olympic style lifters. O'Shea (5) described FI as an advance training method having the intrinsic potential to push the lifter toward his/her upper physical and psychological strength potential. Functional isometrics involved highly intense lifting specifically designed to place maximum overload on the muscles and ligaments while allowing for the training of both biomechanically weak and strong leverage positions. Functional isometric lifting utilizes both dynamic and static muscle contractions in pressing, pulling and squatting movements.

In the technical execution of a FI lift such as the squat, the weighted bar rests upon pins in a power rack placed five centimeters below another set of pins in the rack. After assuming a starting squat position (leg angle 90 or 110 degrees), the lifter drives the barbell up to the top set of pins (dynamic phase) then holds it there for three to five seconds (static phase). For each FI lift both a strong leverage (high angle) position and weak leverage (low angle) position are trained using extreme high overloads. For example, in the high angle squat position, squat training loads can approach 160 percent of a lifter's 1 RM parallel squat.

Today, FI lifting is reported to be used successfully by world class shot putters, discus and hammer throwers, and power and olympic style lifters (7, 8). A search of the published research literature revealed only one FI study which dealt with the bench press (4). Therefore, the purpose of this study was to determine the effectiveness of FI in stimulating greater dynamic leg strength and power.

Methods

Ten healthy male college students at Oregon State University, enrolled in an advanced power weightlifting class, volunteered as subjects for the study ($\bar{x}$ age = 20.3 years ± 1.85 years). Of the 10 subjects, two were athletes (wrestling and crew) with a strong weight training background. The remaining eight subjects had at least one year of weightlifting experience. None of the subjects had previous exposure to power or FI lifting. The use of subjects for this study was approved by the Human Subjects Committee at Oregon State University.

A two-week preconditioning period preceded the six-week experimental period. During this period the subjects performed general strength conditioning exercises and were instructed in the technique of the FI squat and the execution of the parallel squat. Following the preconditioning period, pretesting was conducted. The results of the test were used to pair the subjects and then randomly assign them to either the experimental functional isometric squat group (FIS) or the dynamic parallel squat group (DS). For the six-week experimental training period, both groups trained Tuesday (heavy day) and Friday (light to medium day) afternoons for approximately 60 minutes (**Tables 1** and **2**). Training days were divided into heavy and light workouts to provide sufficient time for physiological recovery and to prevent overtraining. Training loads of the two groups were equal in terms of volume and intensity. During the experimental period, no other type of leg training was permitted. However, upper body training took place on Monday and Thursday.

The FIS group trained according to the method outlined by O'Shea (7, 8). The subjects trained in two squat positions: 1) a low angle position in which the starting knee angle was 90 degrees and, 2) a high angle position having a starting knee angle of 110 degrees. The six-week experimental FIS group followed a periodized training program that was divided into three cycles (**Table 1**). For each cycle a set percentage of a subject's pretest parallel squat 1 RM was used to determine the training load for a given number of repetitions and sets. At the start of cycles two and three, the training loads were increased by 10 percent in the low angle position and 15 to 20 percent in the high angle position. Each training session was organized as follows: 1) warm-up, stretching and light parallel squatting; 2) functional isometric squat, low angle position followed by the high angle; 3) cool-down, one set of very light parallel squats, stretching, eight minutes of stationary biking. Some light parallel squatting was required to maintain technique and to exercise the muscles through a full range of movement to minimize potential injuries associated with 1 RM lifting.

The DS group also followed a periodized training program that paralleled the FIS program (**Table 2**). The six-week training period consisted of three two-week cycles (**Table 2**). Training intensity was based on the pretest parallel squat 1 RM for a given number of sets and repetitions. Procedures for warm-up and cool-down were the same as outlined for the FIS group.

Testing was conducted on a pre- and posttest basis and, due to possible diurnal variations in strength, all tests were conducted at the same time of the day (9). Static leg strength was assessed through the use of the knee extension cable tensiometer as described by Clark and Clark (1). Assessment of dynamic leg strength was determined by a 1 RM in the parallel squat according to the technique described by O'Shea (6). The vertical jump test was used to measure dynamic leg power (1).

Results

Paired t-tests were used within the FIS and the DS groups on each of the variables. One-way analysis of covari-

Table 1. Functional Isometric Squat Program.

1. Warm-up
   A. Stretching - back and legs for 5 minutes
   B. Parallel squat:
      Cycle 1 - 1 x 10 at 60 kg
      1 x 10 at 85 kg
      Cycle 2 - 1 x 10 at 60 kg
      1 x 10 at 95 kg
      Cycle 3 - 1 x 10 at 60 kg
      1 x 7 at 95 kg
      1 x 5 at 105 kg
2. Functional Isometric Squat
   A. Low angle position:
      Warm-up
      60 x 5 (2 second hold)
      85 x 5 (2 second hold)
      Week 1 and 2
      Tuesday - 60-65% of full squat 1 RM 2 x 3 (3 second hold)
      Friday - 40-45% of full squat 1 RM 2 x 3 (3 second hold)
      Week 3 and 4
      Tuesday - 70-75% of full squat 1 RM 2 x 3 (3 second hold)
      Friday - 50-55% of full squat 1 RM 2 x 3 (3 second hold)
      Week 5 and 6
      Tuesday - 80-85% of full squat 1 RM 2 x 3 (3 second hold)
      Friday - 55-65% of full squat 1 RM 2 x 3 (3 second hold)
   B. High angle position:
      Warm-up
      105 x 3 (2 second hold)
      125 x 2 (2 second hold)
      Week 1 and 2
      Tuesday - 120-125% of full squat 2 x 3 (3 second hold)
      Friday - 90-95% of full squat 2 x 3 (3 second hold)
      Week 3 and 4
      Tuesday - 135-140% of full squat 2 x 3 (3 second hold)
      Friday - 105-110% of full squat 2 x 3 (3 second hold)
      Week 5 and 6
      Tuesday - 150-155% of full squat 2 x 3 (3 second hold)
      Friday - 120-125% of full squat 2 x 3 (3 second hold)
   C. Cool down
      1. Parallel squat 1 x 10 at 60 kg
      2. Stretching - 5 minutes
      3. Stationary bike riding - 8 minutes

Table 2. Dynamic Squat Program.

1. Warm-up

   A. Stretching - back and legs for 5 minutes

2. Dynamic Squat

   B. Cycle 1 - Week 1 and 2
   70-75% of 1 RM

   Warm-up
   1 x 10 at 60 kg
   1 x 10 at 75 kg
   Tuesday - 3 x 10 at 70-75% of 1 RM
   Friday - 3 x 10 at 60% of 1 RM
   Warm down - 1 x 10 at 60 kg

   Cycle 2 - Week 3 and 4
   80-85% of 1 RM

   Warm-up
   1 x 10 at 60 kg
   1 x 7 at 80 kg
   1 x 5 at 90 kg
   Tuesday - 3 x 5 at 80-85% of 1 RM
   Friday - 3 x 7 at 65% of 1 RM
   Warm down - 1 x 10 at 60 kg

   Cycle 3 - Week 5 and 6
   90-95% of 1 RM

   Warm-up
   1 x 10 at 60 kg
   1 x 7 at 80 kg
   1 x 3 at 100 kg
   Tuesday - 3 x 2 at 90-95% of 1 RM
   Friday - 3 x 5 at 75% of 1 RM
   Warm down - 1 x 10 at 60 kg

   C. Cool down

   1. Stretching for 5 minutes
   2. Stationary bike riding for 8 minutes

ance (ANCOVA) was used to determine the significant difference between the two training programs with the pretest and the posttest mean score as the dependent variable. Analysis of the parallel squat pre- and posttest data (**Table** 3) indicated that both groups demonstrated a significant improvement at the 0.01 level (Treatment = 0.0030, Control =0.0070). Calculation of the F-values showed that the FIS group exhibited a greater improvement statistically at the 0.05 (0.020) level than the DS group. In static strength both groups experienced a slight decrease. The obtained F-value found no significant difference to exist at the 0.05 (0.790) level for either group. In the vertical power jump, t-test analysis found that the FIS group had a significant improvement at the 0.05 (0.048) level, while the DS group improved at the 0.01 level (0.087). The F-value indicated no significant difference at the 0.05 (0.360) between the two groups.

Discussion

The data generated by this study seems to support the theory that FI training can be an effective method for increasing leg strength as measured by a 1 RM parallel squat. While both groups made significant improvement in dynamic squat strength, the FIS group gain was substantially greater than the DS group (31.8 kg to 13.2, respectively). With an improvement of this magnitude, one could have expected it to be reflected in a highly significant improvement (0.01 level) in both vertical jump power and static strength; however, this was not the case. The FIS group improved only at the 0.05 level in the vertical jump as opposed to the 0.01 level for the DS group. Of interest, too, is that neither group showed any gain in static strength. How to account for this training response or lack of response poses a somewhat complex question. From a logical standpoint, it may be attributed to two factors—training specificity and/or neural fatigue.

First, the dynamic nature of the parallel squat as opposed to the more static FI squat resulted in a greater transfer of strength to the vertical jump. FI lifting involves very little range of movement which may limit optimal strength transfer to full range dynamic movement. Perhaps jump training (plyometrics) needs to be included in FI training in order to facilitate a greater strength transfer.

In accounting for the lack of improvement in static strength by either group, it most likely may be attributed to specificity. Neither the dynamic nor the FI squat movement was specific enough to the static leg extension test. This finding is supported by Hurley, et al (3) who, in studying power lifters, found a low correlation between their dynamic 1 RM squat and their peak torque output measured on the Cybex. There exists, then, a distinct difference in testing single joint movement such as a knee extension and dynamic multiple joint movement like the squat.

Fatigue is the second factor that may have influenced the FIS group's post vertical jump test. In addition to being tested for a 1 RM dynamic squat, these subjects had also peaked out in the FIS squat three days prior. The one day recovery period given before posttesting in the vertical jump may have been insufficient. Considering the existing circumstances, it is reasonable to believe that the FIS subjects were in a mild state of neuromuscular fatigue. This condition would result in a delayed training response which would prevent a maximal performance in the vertical jump.

A day or two longer recovery period may very well have resulted in a better jump performance.

Another question of importance is whether a six-week training cycle can produce optimal improvement in strength and power. The high intense power training cycle was designed to stress the nervous system and to optimize neurological recruitment. Muscle hypertrophy was not a concern of the study. While both training groups realized significant gains in dynamic strength and power, it is difficult to say if a longer training period would have produced better results. The contention here is that it would not have. Subjecting individuals to high stress power-type lifting for long periods of time is risky in terms of potential injuries, overtraining and the often reduced motivation that goes along with it. Perhaps greater gains could have resulted if the first two training cycles had been several weeks longer, thus providing for a broader strength base for the intense third cycle.

Another problem in conducting high stress 1 RM strength studies of this type is the use of non-athletes having relatively limited weightlifting experience. Again, it is rather risky to apply the results to more advanced strength athletes. Presently, it is impossible to say just how trained strength athletes would respond to FI lifting as applied in this study. More research is necessary to determine the exact role of FI lifting as a method of stimulating optimal gains in dynamic strength and power.

Practical Applications

Functional isometric lifting, as utilized in this study, can significantly increase leg strength as measured by a 1 RM squat. When combined with speed and jump training, it can add a new training dimension to athletes specializing in strength-oriented sports such as the field events, football, olympic and power lifting, and on a less intense level to cycling, soccer, ice hockey and skiing. Until more research is conducted as to the exact role FI lifting has in athletic strength training, it is best utilized as supplemental training method during a strength cycle or as a means of maintaining strength in a peaking or competitive cycle (6, 7). FI lifting as based upon the data generated in this study can be especially beneficial to athletes who have reached a strength plateau in the dynamic squat and are finding it difficult to stimulate greater gains.

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Table 3. Statistical Results of Functional Isometric and Dynamic Squat Training Upon the Squat 1 RM Static Strength and Vertical Jump Power

	FIS			DS			
Variable	Pre	Post	t-test	Pre	Post	t-test	ANCOVA
1 RM Squat							
(lbs)	225 (±13.69)	325 (±47.78)	0.003**	278 (±12.75)	307 (±49.02)	0.007**	0.020*
(kg)	115.9 (±6.20)	147.1 (±21.67)		125.3 (±5.78)	139.5 (±22.23)		
Static Strength (tension lbs)	40.60 (±0.84)	39.60(±1.68)	0.170NS	37.80 (±1.30)	38.30 (±4.09)	0.266NS	0.790NS
Vertical Jump (cm)	50.20 (±3.49)	53.60 (±6.01)	0.048*	55.20 (±6.61)	58.18 (±9.09)	0.087**	0.360NS

* 0.05 level of significance
** 0.01 level of significance