Journal of Strength and Conditioning Research, 2004, 18(4), 765–770

Strength/Power Augmentation Subsequent to Short-Term Training Abstinence

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Abstract. Weiss, L.W., L.E. Wood, A.C. Fry, R.B. Kreider, G.E. Relyea, D.B. Bullen, and P.D. Grindstaff. Strength/power augmentation subsequent to short-term training abstinence. *J. Strength Cond. Res. 18(4):765–770. 2004.*—Strength augmentation has been demonstrated in resistance-trained men subsequent to 4 days of training abstinence. However, this phenomenon was exhibited in an unusual circumstance in which the exercise test (seated heel raise) primarily involved an isolated skeletal muscle (soleus) that is normally comprised almost exclusively of 1 fiber type. It is unclear if similar results would be found for aggregate muscle actions. Therefore, a comparable study was designed with this in mind. Subjects were apparently healthy, young, strength-trained men ($n = 25$). All performed various tests of bench press strength at the beginning of their last standardized dynamic constant external resistance (DCER) training session. Subjects were subsequently randomly assigned to 1 of 4 groups and repeated the identical tests at intervals of either 2, 3, 4, or 5 days with no intervening training. Strength tests consisted of 1 repetition maximum (1RM) concentric-only isokinetic bench presses performed at 1.49 and 0.37 $m \cdot s^{-1}$ as well as a 1RM DCER bench press. Measures of peak force and power were obtained from the isokinetic tests and maximum load from the DCER test. Results were expressed in both absolute and relative (to body weight) terms. Subsequent to the 4 abstinence intervals, groups performed similarly ($p > 0.05$) for all dependent variables. Concurrently, however, a small effect size (ES) was found for the group having a 4-day respite for both absolute and relative expressions of peak force and power at the slowest isokinetic bench press velocity. A small ES was also identified for the group having 2 days of rest for relative peak force at the slowest isokinetic test velocity and for relative DCER strength. Therefore, modest and transient strength augmentation appears likely in aggregate muscle actions following 2–4 days of training abstinence in resistance-trained men, but only at relatively slow velocities.

Key Words. preperformance rest, rebound, taper

Introduction

It is currently unclear if an optimal interval of training abstinence exists that temporarily enhances the maximal strength and/or power of heavy-resistance-trained individuals (1, 21, 24). Detraining strength studies have focused on people's ability to retain training effects and, as such, have concentrated on performance decrements with time frames too long to be sensitive to transient performance augmentation (7, 9, 10, 20).

For example, Hortobagyi et al. (9) found that 2 weeks of detraining from dynamic constant external resistance (DCER) training activities reduced ($p < 0.05$) isokinetic eccentric knee extension torque, while no changes occurred in isokinetic concentric knee extension torque, isometric knee extension force, parallel squat strength, free-weight bench press strength, and vertical jump displacement. In addition, Hakkinen et al. (7) reported that 3 weeks of detraining subsequent to 24 weeks of DCER strength training reduced ($p < 0.05$) isometric strength in middle-aged subjects but not in elderly ones. By 24 weeks of detraining, both middle-aged and elderly subjects experienced significant losses ($p < 0.05$) in isometric strength. Furthermore, Weir et al. (20) reported that 8 weeks of detraining following 8 weeks of concentric-only DCER weight training resulted in a significant loss of the training-induced increases in isometric strength but had no effect on 1 repetition maximum (1RM) DCER knee extension strength. Since detraining was the focus of the aforementioned studies, short-term changes in muscular strength over the various detraining periods were not addressed.

In the 2 investigations (1, 24) dealing with the acute effects of training abstinence, results were equivocal. Weiss et al. (24) investigated the acute effects of curtailing dynamic constant external resistance (DCER) strength training (seated heel raise) and found the heel-raise strength of young men was better ($p < 0.05$) after 4 days of abstinence as compared to 2 days and 5 days. DCER performance at 3 days was similar to that found at 4 days. At the same time, isokinetic plantar flexion peak torque at 1.05 and 3.14 $rad \cdot s^{-1}$ was unchanged ($p > 0.05$) over the 5-day rest interval. When effect size (ES) was calculated for these same variables, a small ES was found for groups having 3 or 4 days of rest for heel-raise strength, a small one for the group having 4 days of rest for slow-velocity plantar flexion torque, and a moderate one for the group having 4 days of rest for fast-velocity plantar flexion torque. In this particular study (24), the knees were flexed at 90° during the plantar flexion motion for both the DCER and the isokinetic test. The flexed-knee position diminishes the contribution of the gastrocnemius muscle and increases the role of the soleus muscle, circumstances that may have influenced the results, as the soleus in humans is typically comprised largely of slow-twitch oxidative motor units (12).

In another study, Anderson and Cattanach (1) determined the effects of training abstinence by Division I track and field athletes on 2 different multiple-joint heavy-resistance activities. They found that abstinence of 2, 4, and 7 days from heavy-resistance training did not differentially affect ($p > 0.05$) DCER strength in the bench press or squat. They concluded that strength training should be discontinued 2–7 days prior to an event that demands an expression of maximal strength. However, as strength was not evaluated on consecutive days, a transient augmentation on a particular day may have been missed.

Numerous tapering studies (2, 3, 9, 17) have reported strength and/or power augmentation subsequent to reduced training volume. However, none of these studies curtailed training completely, a logistical circumstance that commonly occurs in athletics, research studies, and clinical testing.

A commonly used training model that incorporates a taper prior to strength/power performance appears to support the general concept of rest-related augmentation (rebound or overcompensation). Periodization is a training paradigm designed to elicit maximal strength/power performance on designated occasions. This year-round method of training uses the gradual cycling over time of volume, intensity, and exercise specificity in order for an athlete's strength and/or power to peak at particular times (4, 19). In general, during early phases of training, volume is high and intensity is moderate. As training progresses toward a time at which the highest strength and/or power are desired, volume is reduced and intensity increased. At the end of this taper, the well-rested trainee is expected to be able to exhibit a peak in muscular strength and/or power.

However, though the taper used in periodization training appears to augment strength and/or power performance, the identification of an optimal period of training abstinence before competition or the establishment of its efficacy in general has not been clearly elucidated. If a specific interval for recovery could be identified, this would greatly aid the coach in preparing strength/power athletes to perform and in establishing if this is an important factor to control during research and clinical testing. Since the results of previous research dealing with this issue were equivocal and the only study reporting an abstinence-related augmentation of strength primarily involved an isolated muscle, additional study is warranted, especially if a multiple-joint exercise is incorporated. Therefore, the purpose of this study was to ascertain if an optimal period of abstinence from heavy-resistance training exists for the maximal expression of muscular strength and/or power on a multiple-joint lift.

METHODS

Experimental Approach to the Problem

Subjects

Twenty-five apparently healthy, strength-trained males, ($\bar{X}$ = 24.2 years of age, standard deviation [*SD*] = 3.8), served as subjects for this study. Prior to participation, written informed consent was obtained and a medical history questionnaire completed. At that time, subjects were also screened via auscultation for hypo- and hypertension. Volunteers qualified as participants by being able to bench press 1.25 times their respective body weights using free weights and by reporting the nonuse of growth-stimulating substances such as anabolic steroids, human growth hormone, and creatine monohydrate during the previous year. Subjects also reported having systematically participated in heavy-resistance training for at least the previous 1.5 years.

Procedures

Subjects switched from their current and varied heavy-resistance training routines to a standardized one for 4 weeks prior to the experimental phase of this study. Training involved a short mesocycle consisting of 3 microcycles of heavy-resistance training designed for them to peak at the end of the 4-week interval (Table 1). All participants incorporated the identical set and repetition schema for the core lift, the free weight bench press. Supplemental lifts followed the completed bench press routine and included arm curls, shrugs, and lateral raises. The identical repetition schema was used for the 3 supplemental lifts.

TABLE 1. Standardized heavy-resistance training program used by strength-trained subjects. Exercises included bench press, arm curls, shrugs, and lateral raises. The entire bench press workout was always finished first with the 3 supplementary lifts completed subsequently either as a circuit or as 3 isolated exercises during the same session.

Week	Days	Sets	~RM*
1, 2	Mon, Wed	4	9–10
	Fri	5	7–8
3	Mon, Wed†	6	5–6
	Fri	7	3–4
4	Mon, Wed	8	2
	Fri‡	6	1
5	Mon‡	6§	1

* RM = repetition maximum.
† Test familiarization followed workout.
‡ No supplementary lifts.
§ Additional sets after completion of all pretesting to bring dynamic constant external resistance total to 6.

Each participant kept an exercise log throughout the 4-week training session to assist in motivating them and to verify their appropriate involvement in the prescribed training program. Also, subjects were instructed to continue their typical dietary and sleeping habits.

A single familiarization session took place 2 weeks prior to pretesting to ensure that subjects were comfortable performing the 2 types of strength tests. The lifts included a DCER bench press (Olympic barbells and standard free-weight flat bench) and an isokinetic bench press (Ariel 5000 Multifunction dynamometer, Ariel Dynamics, Inc., Trabuco Canyon, CA) performed at 2 different velocities. Since all participants regularly included the free weight bench press in their training both during and prior to becoming participants in this investigation, the DCER familiarization involved identifying their preferred hand placement and performing 3 repetitions with the testing bar loaded at 61.5 kg.

However, since none of the lifters had previously performed a machine-based, velocity-controlled (isokinetic) bench press, familiarization was more extensive. At this time, the lifter's hand positions on the bar were established, and range of motion was determined. Subjects also practiced 4 single-repetition, maximum-acceleration attempts at each of the 2 bar velocities.

Pretesting took place at the end of the 4-week training period and consisted of a weightlifting warm-up, 5 minutes of rest, 3 1RM attempts at the fast bench press velocity, 3 1RM attempts at the slow bench press velocity, and 3 1RM attempts for the DCER bench press in that order. Repeated isokinetic tests at each velocity were interspersed with 30 seconds of rest. One minute of rest was provided during the switch to the slower bench press velocity. DCER tests commenced 10 minutes later with attempts interspersed with 3 minutes of rest.

Following pretesting, subjects were randomly assigned to 1 of 4 testing groups. Group designation consisted of subjects abstaining from exercise for either 2 ($n = 8$), 3 ($n = 5$), 4 ($n = 5$), or 5 ($n = 7$) days prior to performance. During the respective rest intervals, no weight training activities were permitted. Attrition resulted in the unequal group sizes, as each originally included 8 subjects.

Isokinetic Bench Press. Bench press range of motion (ROM) was established during the familiarization session. Also at that time, preliminary diagnostic tests for maximal bench press strength and velocity were conducted. These were performed to optimize the valve aperture on the hydraulic device (Ariel 5000 Multifunction dynamometer) prior to initiating the lift. Foot and hand positions were standardized, but because of differences in arm lengths and torso thickness, actual bar ROM varied between subjects. Hand positioning was based on personal preference and held constant during all aspects of data collection.

During testing, subjects assumed a supine position on the bench and lowered the "unloaded" bar prior to maximally thrusting it upward at moderately fast (1.49 $m{\cdot}s^{-1}$) and slow (0.37 $m{\cdot}s^{-1}$) velocities. The downward movement started at 30° of elbow flexion (high position) and continued until the bar touched the anterior surface of the chest (low position) at the nipple level. As we were concerned only with the upward movement, subjects were encouraged to move substantially slower than the preset downward velocity (2.48 $m{\cdot}s^{-1}$). This gave them the sensation of lowering an unloaded bar. The upward phase involved a forceful movement beyond the initial position. This reduced deceleration through the ROM through which measurements were taken. Velocity-spectrum bench presses incorporating this approach have been reported as being highly reliable (23).

Standard warm-up activities were performed by all subjects, including light upper-body stretching (relaxed arm hangs from a stationary bar) for 20 seconds and 4 refamiliarization trials for the isokinetic bench presses. Refamiliarization lifts included 2 1-repetition sets at each of 2 bar velocities (1.49 and 0.37 $m{\cdot}s^{-1}$) starting from the up position.

Isokinetic bench press testing commenced 3 minutes following the completion of all warm-up activities with the fastest velocity performed first. Subjects executed the exercises at each of the previously mentioned velocities using 3 sets of 1RM. A 30-second rest interval was provided between velocity-controlled sets. When switching to the slower velocity, a 60-second rest was provided. The concentric-only nature of this testing device and the small number of repetitions performed resulted in little or no fatigue as reported by the subjects, although the slower test velocity was described as being more difficult.

The Ariel computerized dynamometer was calibrated for force using loads of 54 and 101.1 kg. Force calibrations were checked in duplicate at those same loads prior to each testing session and over the course of the study to establish the precision of the device.

Free Weight (DCER) Bench Press. Free-weight bench press warm-ups and testing commenced 10 minutes after the isokinetic tests. Warm-up bench presses included 2 sets of 10 repetitions at 70% of the estimated 1RM. Testing commenced 5 minutes following the completion of the warm-up lifts and included 3 1RM attempts. This procedure was adequate to ascertain DCER strength, as all lifters were familiar with their bench press capabilities. A highly skilled spotter was always utilized to ensure subject safety. The bar position for the free-weight bench press began in the up position at full elbow extension, moved to chest level for a momentary pause, and finished back at the starting position. Hand and foot positions were determined for each subject during familiarization and were held constant during all testing.

Lifting suits were not used on the pre- or posttests. If accustomed to wearing a weightlifting belt while bench pressing, the subject was permitted to do so during testing, given that it would have no impact on the 1RM capability of the lifter. All lifters had to maintain foot contact on the floor during the lift while keeping their hips on the bench. No bouncing of the bar off the chest was allowed. All 1RM attempts began with the spotter assisting the subject in moving the bar to the starting position, after which the lifter proceeded at his own discretion. However, the bar had to descend in a smooth, controlled manner until it just touched the chest, after which it was returned in 1 continuous motion to the starting position.

Statistical Analyses

The precision of the isokinetic dynamometer was statistically analyzed using intra- and intertest coefficients of variation (CV) for each of the 2 testing loads. Acceptable CV values needed to be less than 15% (16).

Pretest bench press data were analyzed to determine if groups were initially homogeneous for all dependent variables. In addition, the association of pretest to posttest data was determined. We expected to find homogeneity of variance on pretest data and for the pretest and posttest scores to be significantly correlated. That being the case, groups would be compared via analysis of covariance (ANCOVA). Pretest scores for the respective variables would be used as covariates for the posttest scores. Alpha was set at 0.05. Multiple comparisons were to be accomplished via least significant differences when appropriate. SPSS (SPSS, Chicago, IL) 11.5 for Windows (Microsoft, Redmond, WA) was used for all statistical analyses.

ES was also calculated for each group on all dependent variables and is especially useful in determining if the magnitude of differences between groups is of practical significance (13–15, 18).

RESULTS

Intra- and intertest CV values for 54.0- and 101.1-kg loads on the isokinetic dynamometer were $\leq$3%. In addition, Hortobagyi et al. (8) reported that the same type of device produced reliable muscle mechanical data for a single isokinetic velocity and for a single isotonic load on bench press and squat exercises. Furthermore, Weiss et al. (22) and Weiss (23) reported high reliability for force and power measures over a broad spectrum of velocities during bench press and squat exercises on the same dynamometer. Considered collectively, this information suggests that the type of isokinetic dynamometer used in this investigation can produce precise measurements and that when bench presses are performed on the same device at multiple velocities, reliable force and power data can be obtained.

Homogeneity of variance of the 4 groups was estab-

TABLE 2. Bench press pretest used as covariate. Group designations were 1 = 2 days, 2 = 3 days 3 = 4 days, 4 = 5 days.*

Dependent Variable	Group	$\bar{X}$	$SE_{\bar{X}}$	ES
1RM (kg)	1 (n = 8)	138.9	1.6	0.15
F ratio = 0.721	2 (n = 5)	136.8	2.0	0.08
p = 0.55	3 (n = 5)	135.4	2.0	0.03
1 − β = 0.82	4 (n = 7)	136.4	1.8	0.07
Relative 1RM	1 (n = 8)	1.58	1.54	0.27†
F ratio = 1.907	2 (n = 5)	1.52	1.47	0.04
p = 0.16	3 (n = 5)	1.52	1.46	0.04
1 − β = 0.58	4 (n = 7)	1.53	1.48	0.08
Peak force (N) at 0.37 m·s^{-1}	1 (n = 7)	1,351.3	37.0	0.12
F ratio = 0.736	2 (n = 5)	1,295.0	43.7	−0.11
p = 0.54	3 (n = 5)	1,385.1	43.7	0.26†
1 − β = 0.82	4 (n = 7)	1,338.1	36.9	0.07
Relative peak force at 0.37 m·s^{-1}	1 (n = 7)	15.25	0.49	0.27†
F ratio = 0.560	2 (n = 5)	14.43	0.58	0.10
p = 0.65	3 (n = 5)	15.32	0.57	0.30†
1 − β = 0.86	4 (n = 7)	14.77	0.48	0.05
Peak force (N) at 1.49 m·s^{-1}	1 (n = 8)	735.9	24.1	−0.13
F ratio = 0.243	2 (n = 5)	749.9	30.2	−0.06
p = 0.87	3 (n = 5)	764.8	30.5	0.02
1 − β = 0.91	4 (n = 8)	760.8	25.5	0.00
Relative peak force at 1.49 m·s^{-1}	1 (n = 8)	8.30	0.29	−0.11
F ratio = 0.081	2 (n = 5)	8.43	0.37	−0.03
p = 0.97	3 (n = 5)	8.51	0.36	0.03
1 − β = 0.94	4 (n = 7)	8.43	0.30	−0.03
Peak power (W) at 0.37 m·s^{-1}	1 (n = 7)	561.8	16.7	0.16
F ratio = 1.170	2 (n = 5)	530.2	19.8	−0.13
p = 0.35	3 (n = 5)	582.1	19.9	0.35†
1 − β =0.74	4 (n = 7)	559.6	16.8	0.14
Relative peak power at 0.37 m·s^{-1}	1 (n = 7)	6.38	0.22	0.35†
F ratio = 1.907	2 (n = 5)	5.86	0.25	−0.17
p = 0.16	3 (n = 5)	6.43	0.25	0.40†
1 − β = 0.58	4 (n = 7)	6.18	0.22	0.15
Peak power (W) at 1.49 m·s^{-1}	1 (n = 8)	925.0	32.8	0.06
F ratio = 0.482	2 (n = 5)	875.0	41.2	−0.15
p = 0.70	3 (n = 5)	903.3	41.9	−0.03
1 − β = 0.87	4 (n = 7)	934.7	34.7	0.10
Relative peak power at 1.49 m·s^{-1}	1 (n = 8)	10.53	0.38	0.19
F ratio = 0.541	2 (n = 5)	9.78	0.51	−0.17
p = 0.66	3 (n = 5)	10.04	0.49	−0.03
1 − β = 0.86	4 (n = 7)	10.39	0.41	0.12

* $\bar{X}$ = mean; $SE_{\bar{X}}$ = standard error of the mean; ES = effect size; 1RM = 1 repetition maximum.
† Small ES.

lished for all pretest variables. In addition, pre- and posttest variables were highly related. Therefore, ANCOVA was used to analyze posttest data. Groups were similar ($p > 0.05$) for all dependent variables, including free weight (DCER) bench press strength and isokinetic bench press peak force and power at both 1.49 and 0.37 m·s^{-1}. Statistical power was modest for 3 of 10 comparisons (0.58 to 0.74) and high (>0.80) for the rest (Table 2).

In considering the magnitude of differences for the various preperformance abstinence intervals, a small positive ES was found at 4 days for peak force, relative peak force, peak power, and relative peak power for isokinetic bench presses performed at 0.37 m·s^{-1}. A small ES was also found at 2 days for relative DCER strength and relative peak force for isokinetic bench presses performed at 0.37 m·s^{-1}. Trivial effect sizes were discerned for all variables for isokinetic bench presses performed at 1.49 m·s^{-1} as well as for absolute DCER 1RMs (Table 2).

DISCUSSION

From the current investigation, results of the ANCOVA suggest that the effects of abstaining from DCER strength training were similar ($p > 0.05$) at 2, 3, 4, or 5 days posttraining for DCER bench press absolute and relative strength, slow-velocity bench press peak force and power, and moderately fast velocity bench press peak force and power. However, when ES was calculated, it appears that selected measures of strength were modestly augmented following 2 and 4 days of training abstinence.

Results of the ANCOVA appear to support the findings previously reported by Anderson and Cattanach (1) in which isotonic bench press and squat performances were similar ($p > 0.05$) following 2, 4, and 7 days of rest. Anderson and Cattanach (1) utilized 41 National Collegiate Athletic Association Division I track and field athletes (22 men, 19 women), all of whom were randomly assigned to groups having 1 of the previously mentioned preperformance rest intervals. Prior to testing, subjects performed standardized training for 5 weeks, 3 times per week. At the beginning of the last training session, bench press and squat exercises were tested using 1RMs. No significant ($p > 0.05$) group effects were noted. Therefore, the authors concluded that 2 days of rest was adequate for recovery, while 7 days of rest elicited no demonstrable detraining effect. Their study suggests that inactivity of up to 1 week has a negligible effect on bench press and squat performances.

To date, Weiss et al. (24) appear to have conducted the only investigation in which a posttraining augmentation or rebound was reported. This study utilized young men who had completed 8 weeks of DCER training on a seated heel-raise apparatus. It was determined that strength was significantly ($p < 0.05$) increased at 4 days as compared to 2 days and 5 days of training abstinence and was similar to that found at 3 days. It should be noted that both training and testing were performed with the knees flexed at 90°. This position minimizes the contribution of the biarticular gastrocnemius and maximizes the contribution of the uniarticular soleus, a muscle comprised primarily of slow-twitch oxidative motor units (12). Given that the muscle most involved for the seated heel raise (soleus) is comprised primarily of motor units having a high oxidative capacity suggests it would be premature to generalize from these findings. This study, however, suggests that an abstinence-related transient augmentation in strength expression might be manifest under specific circumstances.

Although not identical, preperformance reduced training or tapering in swimming and running has been shown to enhance endurance and strength (2, 3). It has also been shown to enhance strength in heavy-resistance-trained individuals (6). Tapering does not ordinarily involve the cessation of exercise but rather a reduction in its volume. Strength augmentation may be pronounced consequent to taper, especially if an individual is in a state of overreaching (5, 11). This suggests that systematically reducing training volume at an appropriate time may enhance recovery and promote supercompensation to the training stresses.

The small and unequal group sizes in the present study contributed to the modest statistical power found for some dependent variables (relative 1RM, peak power at 0.37 $m \cdot s^{-1}$, relative peak power at 0.37 $m \cdot s^{-1}$). These circumstances create an environment in which it is more likely that actual group differences will go undetected. ES calculations provide a more revealing picture concerning the relevance of various treatment effects (13–15, 18). ES calculations in the present study suggest that the group abstaining from resistance training for 4 days had modestly augmented force and power output for slow-velocity isokinetic bench presses. In addition, the group that abstained for 2 days also had modestly augmented performance for slow-velocity isokinetic force and DCER bench presses when expressed relative to body weight.

Although not a huge effect, it appears that some augmentation of strength and power may occur when resistance training is curtailed approximately 4 days prior to performance. This corroborates findings reported previously in a similar study (24). The apparent augmentation is transient, and it is unclear if anything can be done to enhance it or if it is more pronounced in certain individuals. It is clear, however, that multiple measures of strength and power are uncompromised in young men subsequent to abstinence from resistance training for at least 5 days. Additional study in this area is warranted.

PRACTICAL APPLICATIONS

The lack of research in this area is somewhat surprising given the importance of this question for athletes needing high strength and power. At best, potential practical applications concerning preperformance abstinence are tentative, although it appears that circumstances exist in which strength may be modestly and transiently augmented in young resistance-trained men at about 4 days posttraining.

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