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Comparison of 1 Day and 3 Days Per Week of Equal-Volume Resistance Training in Experienced Subjects

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ABSTRACT

There is not a strong research basis for current views of the importance of individual training variables in strength training protocol design. This study compared 1 day versus 3 days of resistance training per week in recreational weight trainers with the training volume held constant between the treatments. Subjects were randomly assigned to 1 of 2 groups: 1 day per week of 3 sets to failure (1DAY) or 3 days per week of 1 set to failure (3DAY). Relative intensity (percent of initial 1 repetition maximum [1RM]) was varied throughout the study in both groups by using a periodized repetition range of 3–10. Volume (repetitions × mass) did not differ ($p \leq 0.05$) between the groups over the 12 weeks. The 1RMs of various upper- and lower-body exercises were assessed at baseline and at weeks 6 and 12. The 1RMs increased ($p \leq 0.05$) significantly for the combined groups over time. The 1DAY group achieved ~62% of the 1RM increases observed in the 3DAY group in both upper-body and lower-body lifts. Larger increases in lean body mass were apparent in the 3DAY group. The findings suggest that a higher frequency of resistance training, even when volume is held constant, produces superior gains in 1RM. However, training only 1 day per week was an effective means of increasing strength, even in experienced recreational weight trainers. From a dose-response perspective, with the total volume of exercise held constant, spreading the training frequency to 3 doses per week produced superior results.

Key Words: exercise, physical activity, training frequency, strength gains, weight training

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Introduction

Much of the fundamental knowledge of weight training is based on studies of subjects with little or no experience (3–6, 16). The present study examined the effects of 2 different frequencies of resistance training on strength and muscle mass in experienced recreational weightlifters while holding total volume per week constant.

The purpose of the study was to determine, in strength training–experienced subjects, if low-frequency (1 day per week) training could have a comparable effect to higher frequency (3 days per week) training when the total volume is held constant. It should be noted that both training protocols were of a low volume, which could have had some impact on the results. Also, the findings may have differed if a protocol of periodization had been implemented.

Because high-frequency training is very difficult for most athletes during the season as well as for nonathletes, physical therapy patients in rehabilitation, and astronauts in space, it is important to evaluate the effectiveness of lower-frequency and lower-volume protocols in the production of strength gains. This study would provide valuable information that might conserve training time and encourage participation, as well as add to the existing body of knowledge on training variables and dose-response issues.

Many of the studies that formed the basis for our present strength-training principles actually observed only small differences between various combinations of repetitions, sets, and frequencies, and some studies did not show any significant difference at all when comparing various resistance training protocols (5, 14, 16). In addition, a more recent study found essentially no difference between the performance of 1 set and 3 sets when subjects exercised 3 times per week (20).

Recent focus in strength training seems to have shifted to the investigation of training frequency and significant frequency-related differences have been found, such as the effects of 2 versus 3 training sessions per week (6, 9). It should be kept in mind that in the study conducted by Braith et al. (6), the lower-frequency group (2 days per week) attained ~80% of the isometric strength increases observed in the higher-frequency group (3 days per week). However, the previously mentioned investigations were almost always conducted on inexperienced, often sedentary subjects. It is interesting to note that as the training experience before the onset of the study protocol increased, i.e.., by only 2 weeks (9), differences between frequencies of training tended to be less than differences found in studies conducted with subjects who were sedentary prior to the study (6).

The association of the subjects' training experience with study outcomes obviously reflects the effects that neural factors have on the course of muscular strength development. It has been reported, for example, that by strength training 1 limb, the untrained limb will experience significant increases in strength with little or no increase in muscle cross-sectional area (11, 12, 15, 17). One explanation for the large contributions by neural development to early strength gains is that training better enables subjects to recruit all available motor units, to recruit at a high enough firing rate to produce maximal force, or to achieve some combination of these 2 processes (8, 18). Whatever the explanation, subject training experience must be taken into account when devising or evaluating exercise programs.

It has not been clearly established whether our current training principles are the most effective means for producing strength increases in experienced subjects or the general population. All strength-training programs are effective to some extent, but there is a need to know the most time-efficient means for increasing strength. In order to elucidate these methods, dose-response issues in all the variables of resistance training should be carefully investigated.

Methods

Subjects

Twenty-five healthy subjects (n = 14 men; n = 11 women), recreationally experienced in free-weight training volunteered to participate in the study. To be eligible, each was required to have resistance-trained consistently with a protocol of 3–4 days per week and each major muscle group had to be trained at least twice per week. Subjects had to have trained for at least 12 weeks (24 workouts) immediately prior to initiation of the study. None of these subjects were competitive lifters or bodybuilders, but all were very knowledgeable about resistance training. Subjects were randomly assigned to 1 of 2 groups: 1 day per week of 3 sets to failure (1DAY) or 3 days per week of 1 set to failure (3DAY).

After excluding 7 subjects who did not meet compliance requirements, the 1DAY group was comprised of 7 men and 2 women (mean ± *SD*: age, 26.0 ± 3.8 years; weight, 77.1 ± 9.8 kg), and the 3DAY group was comprised of 5 men and 4 women (age, 23.8 ± 5.4 years; weight, 72.1 ± 21.9 kg). There were no statistically significant initial differences in the means between the groups for any physical or strength variable. The 1DAY group did contain fewer women and had a greater amount of resistance-training experience (6.3 ± 4 years) when compared with the 3DAY group (4.2 ± 2.8 years). Subjects were asked to maintain dietary and activity habits during the study as close as possible to those prior to the study. Written informed consent in accordance with the procedures for the protection of human subjects set forth by the local Institutional Review Board was obtained prior to testing. Physical characteristics of the subjects are listed in Table 1.

Experimental Design

Beginning intensities for resistance training were set at 80% of the subject's 1 repetition maximum (1RM). The 1DAY group resistance trained 1 day per week, performed 3 sets of each exercise, and recovered for approximately 2 minutes between sets. When 10, 9, and 8 repetitions were possible on the first, second, and third sets, respectively, the load was increased by 2.3–9.1 kg in order to lower the repetitions performed on the first set to 5. The 3DAY group trained 3 days per week and performed 1 set of each exercise. When 10 repetitions were possible in the set, the load was increased by 2.3–9.1 kg in order to lower the possible repetitions to 3. The number of sets chosen for the groups was based on the need to keep total work volume constant. If the 3DAY group performed multiple sets, it would have been extremely difficult to evaluate what percentage of the strength increases was attributable to volume differences and what percentage to frequency differences. In other words, in order to isolate the variable of frequency and elucidate the affect of daily volume, total volume per week had to be held constant. The rotating repetition scheme was implemented in order to equalize the training intensities and load volumes (repetitions × mass) of the groups. Both exercise groups were instructed to perform each set to momentary muscular failure. Subjects were asked to rate their level of delayed onset muscle soreness on a scale of 1–10 (1, little or no muscle soreness; 10, extreme muscle soreness). The exercises performed and the corresponding targeted muscle groups for the resistance training protocols were as follows:

1. Supine bench press: pectoralis major
2. Elbow extension (tricep press): triceps brachii
3. Standing lateral arm raise: deltoid
4. Seated arm pull-down (lat pull): latissimus dorsi
5. Elbow flexion (bicep curl): biceps brachii
6. Hip extension (leg press): gluteus maximus
7. Seated knee extension (leg extension): quadriceps
8. Prone knee flexion (leg curl): hamstrings
9. Standing heel raise (calf raise): gastrocnemius

Table 1. Subject characteristics (mean ± *SD*; *N* = 18).

	Group							
	1DAY				3DAY			
	Men $n = 7$		Women $n = 2$		Men $n = 5$		Women $n = 4$	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Age (y)	24.7	±3.1	30.5	±2.1	20.4	±2.6	28.0	±5.2
Height (cm)	180.4	±6.0	165.1	±3.5	180.3	±8.1	163.2	±10.1
Mass (kg)	79.4	±6.5	69.0	±18.8	84.3	±22.1	56.9	±8.1
Training (y)	5.71	±3.9	8.5	±4.9	4.0	±2.5	4.5	±3.5
Systolic blood pressure (mm Hg)	117.4	±3.8	110.0	±0.0	112.0	±11.0	109.0	±8.4
Diastolic blood pressure (mm Hg)	65.1	±9.7	58.0	±2.8	61.6	±3.6	63.5	±10.8
Circumferences (cm)								
Chest	98.0	±5.4	94.5	±13.4	99.1	±13.6	87.0	±4.2
Right arm	31.6	±2.0	28.3	±6.7	31.1	±4.5	25.6	±1.3
Left arm	31.5	±2.0	27.5	±6.4	31.2	±4.2	25.63	±1.1
Waist	81.8	±2.9	79.3	±18.0	89.8	±16.4	68.3	±1.7
Right thigh	58.2	±2.0	59.8	±6.0	59.8	±7.1	53.8	±3.3
Left thigh	57.8	±1.7	59.5	±5.7	59.6	±7.6	54.0	±2.8
Right calf	37.6	±2.2	36.8	±2.5	38.8	±4.7	34.5	±2.3
Left calf	37.6	±2.4	37.0	±2.8	38.6	±4.9	34.5	±2.0
Hips	98.1	±3.7	102.6	±4.9	102.7	±10.4	96.5	±6.6
Sum	532.4	±19.1	525.1	±66.4	550.7	±71.6	479.7	±19.0
Skinfold thickness (mm)								
Upper-body	5.7	±1.6	17.5	±10.6	12.6	±10.3	14.0	±4.7
Midbody	14.1	±5.1	12.5	±7.8	21.4	±13.0	10.8	±3.4
Thigh	11.9	±5.1	22.5	±9.2	13.0	±4.7	19.0	±4.2
Sum	31.7	±8.8	52.5	±27.6	47.0	±27.6	43.8	±9.8
Body fat (%)	8.9	±2.9	21.0	±9.9	12.8	±7.9	18.1	±3.4
Lean body mass (kg)	72.3	±5.6	53.6	±8.1	72.2	±12.0	46.7	±7.7

Experimental Protocols

Body density, percent body fat, and subsequently, percent lean muscle tissue were estimated through the use of Lange skinfold calipers (Cambridge, MA) and the 3-skinfold-site Jackson and Pollock equation (men: chest, abdomen, and thigh; women: triceps, suprailiac, and thigh). Circumference measurements were taken at the upper arm, abdomen, thigh, and calf with a cloth measuring tape. All measurements were taken by the same experienced technician in accordance with the American College of Sports Medicine's guidelines (1). All measurements were taken pre- and posttraining.

For each exercise in the strength-training protocol, a light load (easily allowing 10 repetitions) was used as a warm-up prior to the strength test. A 1RM was established for each lift by increasing the load by 2.3–9.1 kg (depending on the level of difficulty) after each successful lift until the maximum was reached. During subsequent strength tests (or on the first test if the subject knew their prior 1RM), a warm-up was performed with 60% of the previous 1RM, followed by 1 repetition each with 80, 85, 90, and 95% of 1RM. Thereafter, 2.3–9.1 kg were added upon each successful lift until the maximum was reached. Each subject was allowed 2–3 minutes between attempts. Strength tests were performed pretraining, midtraining (6 weeks), and again posttraining (12 weeks). Each subject's blood pressure was measured prior to and after participation in the study using a standard aneroid sphygmomanometer.

Statistical Analysis

Means and standard deviations of initial physical characteristics were computed for both groups (Table 1). Significant differences between the means at 0, 6, and 12 weeks were tested using a multivariate analysis of covariance (MANCOVA) with repeated measures. Analysis of covariance was used in order to control for mixed-gender groups. Sex was used as the covariate. The MANCOVA *F* tests were followed by univariate analyses for all significant effects. When significant F values were found, Tukey's Honestly Significant Difference post hoc comparisons were used to test whether differences exist between specific group means.

Statistical procedures were performed using the

Table 2. Upper-body performance variables (mean ± *SD*; *N* = 18).

	Group					
	1DAY			3DAY		
	Mean	*SD*	Increase (%)	Mean	*SD*	Increase (%)
1 Repetition maximum (kg)						
Bench press						
Pre	75.61	±27.8		54.19	±25.7	
6 Weeks*	79.90	±29.2	5.7	62.76	±28.9	15.8
Post*	83.62	±30.6	10.6	68.90	±27.5	27.1
Lat pull						
Pre	65.07	±20.9		53.83	±19.0	
6 Weeks	70.06	±21.1	7.7	59.29	±19.6	10.1
Post*	77.76	±22.9	19.5	63.73	±21.2	18.4
Tricep press						
Pre	30.43	±10.3		20.97	±9.9	
6 Weeks*	33.64	±11.4	10.5	25.09	±8.8	19.6
Post*	38.20	±13.5	25.5	27.72	±7.1	32.2
Bicep curl						
Pre	35.01	±14.8		25.46	±12.6	
6 Weeks*	38.82	±15.3	10.9	31.50	±16.0	23.7
Post*	43.08	±16.8	23.1	35.17	±14.0	38.1
Lateral raise						
Pre	22.69	±7.5		16.33	±6.6	
6 Weeks*	27.21	±9.4	19.9	21.87	±10.3	33.9
Post*	32.32	±10.5	42.4	27.22	±10.6	66.7
Total upper-body 1RM						
Pre	228.83			168.16		
6 Weeks*	249.61		9.1	197.09		17.2
Post*	275.01		20.2	222.72		32.4
Total upper-body load volume						
First 6 weeks	22,368.34			18,125.91		
Second 6 weeks	24,929.13			18,919.36		

* Significantly different ($p \leq 0.05$) from the previous trial for the combined groups.

Statistical Analysis System general linear models procedure. Statistical significance was accepted at $p \leq 0.05$. One weakness of the study was small sample size. However, small sample size primarily affects statistical power. Though low power decreases the ability to detect a significant difference, most of the major inferences drawn from the study were not affected by statistical power. Trends were noted.

Results

All upper-body 1RMs increased significantly over the 12-week training period for the combined groups, with the 1DAY group achieving ~53% of the improvement experienced by the 3DAY group at week 6, and ~62% of the 3DAY group results at week 12. No significant interactions occurred. The 1RMs for bench press, lat pull, tricep press, bicep curl, lateral raise, and total upper body, along with their respective percent increases are shown in Table 2. Total upper-body 1RM and percent increases are displayed in Figure 1.

All lower-body 1RMs increased significantly over the 12-week training period for the combined groups, with the 1DAY group achieving ~58% of the improvement experienced by the 3DAY group at week 6, and ~63% of the 3DAY group results at week 12. The only significant interaction was for the 1RM leg press, showing that the 3DAY group increased more (46%) than the1DAY group increased (22%) over 12 weeks. The 1RMs for leg press, leg extension, leg curl, calf raise, and total lower body, along with their respective percent increases are shown in Table 3. Total lower-body 1RM and its percent increases are displayed graphically in Figure 1.

A significant decrease in resting systolic blood

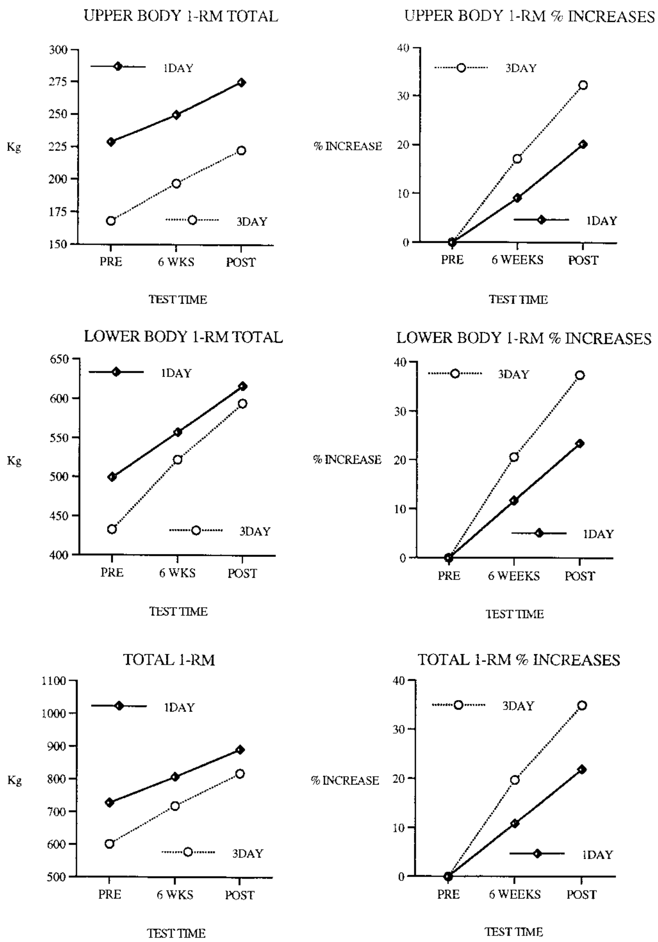

Figure 1. Mean absolute and percentage increase for upper-, lower- and total body for groups training 3 sets 1 day per week (1Day) (n = 9) and 1 set 3 days per week (3Day) (n = 9), before (pre), after 6 weeks, and after 12 weeks (post).

pressure was observed for the combined groups over time, with the 1DAY group experiencing a 5% decrease, and the 3DAY group experiencing a 3% decrease (Table 4). Also, a nonsignificant trend toward decreased resting diastolic blood pressure was noted over time; the 1DAY group experienced a ~4% decrease and the 3DAY group experienced a ~9% decrease.

No significant differences in body mass, skinfold thickness, percent body fat, or circumference measurements occurred (Table 4). A nonsignificant trend toward increased lean body mass was noted over time; the 1DAY group experienced an ~1% increase and the 3DAY group experienced an ~8% increase. A nonsignificant trend toward decreased body fat percentage was also evident. Percent body fat decreased ~0.7 percentage points in the 1DAY group and ~1.2 percentage points in the 3DAY group.

Discussion

The variables of frequency, intensity, and duration of exercise are often studied. However, most studies examine untrained subjects who are known to respond well to almost any training program due to neural factors (3–6, 8, 11, 12, 15–18). The observed data support the conclusion that 1-day-per-week training produced 1RM strength gains comparable to those of a 3-day-per-week protocol in experienced recreational lifters when total volume per week were held constant. One day of training per week resulted in a strength increase of ~62% the in the 3DAY group. This finding demonstrates a large contribution of volume per session for a given training protocol design because total work volume was held constant. Also, greater increases in strength were observed in the higher-frequency group with an equal volume of training per week, suggesting that frequency is a key factor in strength adaptations.

It should be noted that the 3DAY group contained more women than the 1DAY group, but also experienced the greatest gains in strength. This finding supports previous studies that have shown minimal sex-differences in response to similar weight-training regimens (7, 22).

Resistance training caused significant increases in 1RM for the combined groups over time without significant interaction effects, with the exception of the leg press. Figure 1, depicts increases in 1RM over the 12 weeks and reveals slightly faster strength gains in the 3DAY group, but also a convergence upon those increases by the 1DAY group.

Though no statistically significant group interactions were found for upper-body 1RMs, a definite trend was observed. As can be seen in Table 2 and Figure 1, the 3DAY group experienced greater percent increases than the 1DAY group in all 1RMs except in the lat pull-down 1RM, in which the groups were almost even. The 27.1% increase in bench press 1RM for the 3DAY group was very similar to the 30% increase observed by Berger (3) in inexperienced subjects using a 3-set, 3-day-per-week program. Berger's (3) subjects (inexperienced and using a higher volume of training) and the subjects in the 3DAY group (experienced and using a lower volume of training) having essentially the same results supporting the hypothesis that experienced strength trainers may not need as high a frequency or volume of training to obtain the same strength gains. In addition, percent increases in bicep curl 1RM in the 1DAY group (23.1%) were similar to those found by Silvester et al. (19) using a 1-set, 3-day-per-week protocol (24.6%). Also, the 3DAY group experienced percent increases in bicep curl 1RM (38.1%) that were actually larger than those found in the study of Silvester et al. (19) in their 3-set, 3-day-per-week group (26.2%). Only minimal comparison can be made on the basis of 2 exercises alone, but these data provide evidence that a single set of resistance exercise performed 3 days per week by moderately and recreationally trained subjects can produce results similar to

Table 3. Lower-body performance variables (mean ± *SD*; *N* = 18).

	Group					
	1DAY			3DAY		
	Mean	*SD*	Increase (%)	Mean	*SD*	Increase (%)
1 Repetition maximum (kg)						
Leg press						
Pre	200.32	±83.1		191.27	±96.3	
6 Weeks*	223.79	±84.1	11.7	240.90	±113.7	25.9
Post*	244.92	±80.9	22.3	279.52	±114.3	46.1
Leg extension						
Pre	62.81	±13.6		66.60	±15.7	
6 Weeks*	73.82	±17.2	17.5	76.44	±14.8	14.8
Post*	84.22	±19.9	34.1	88.38	±17.1	32.7
Leg curl						
Pre	57.51	±15.5		43.14	±17.5	
6 Weeks*	64.62	±17.2	12.4	52.03	±22.4	20.6
Post*	72.01	±19.0	25.2	63.50	±24.9	47.2
Calf raise						
Pre	178.01	±24.2		131.69	±46.0	
6 Weeks*	195.47	±19.0	9.8	152.51	±44.6	15.8
Post*	215.11	±15.3	20.8	162.98	±42.5	23.8
Total lower-body 1RM						
Pre	499.19			432.66		
6 Weeks	557.70		11.7	521.91		20.6
Post*	616.26		23.5	594.38		37.4
Total lower-body load volume						
First 6 weeks	59,409.03			60,869.46		
Second 6 weeks	64,493.93			68,857.53		

* Significantly different ($p \leq 0.05$) from the previous trial for the combined groups.

those of a 3-set program. Therefore, if similar results can be obtained with a lower volume of training, and even better results can be produced with a higher frequency of training, frequency may be the more important of the 2 variables. However, at least in our paradigm, volume definitely made a large contribution.

As previously mentioned, a statistically significant interaction effect was observed for the 1RM leg press, with the 3DAY group experiencing an increase (46%) greater than the corresponding increase in the 1DAY group (22%) during the 12-week training period. A large percent increase was also observed in leg curl 1RM, with the 3DAY group experiencing larger percent increases (47.2%) than the 1DAY group (25.2%). The very large increases in the 3DAY group 1RMs for these 2 lifts could account for the greater improvement of the 3DAY group apparent in Figure 1 for the lower-body 1RM total as compared with the upper-body 1RM total. Percent increases in leg curl 1RM in both groups were greater than the largest percent increase (18.7%, using 1 set of 8–12 reps) reported in 2 previous studies (7, 20) using protocols of 1–3 sets of 8–12 reps, 3 days per week. The very large response in leg curl observed in the 3DAY group was unexpected. However, Starkey et al. (20) found a larger degree of hypertrophy in the hamstrings than in the quadriceps using a 3-day-per-week program. The hamstrings may be underused in daily activity (and therefore relatively untrained) when compared with the quadriceps, thereby enabling greater muscle development. Although not measured individually in this study, a large degree of hypertrophy in the hamstrings could account for the very large increases in leg curl (hamstrings are the prime movers in flexion of the knee) and leg press (hamstrings are synergists in extension of the hip) 1RMs in the 3DAY group. Percent increases in knee extension 1RM for both groups (34.1% in the 1DAY group and 32.7% in the 3DAY group) were comparable to the percent increases (30.1% and 26.8% using 1 set and 3 sets respectively) observed with use of protocols of 1 or 3 sets of 8–12 reps, 3 days per week in untrained subjects (20). Again the pattern observed

Table 4. Health-related variables (mean ± *SD*; $N = 18$).

	Group			
	1DAY		3DAY	
	Mean	*SD*	Mean	*SD*
Body mass (kg)				
Pre	77.12	±9.8	72.10	±21.9
Post	77.52	±9.4	75.68	±19.7
Systolic blood pressure (mm Hg)				
Pre	115.78	±4.6	110.56	±9.5
Post*	110.00	±3.9	107.11	±6.3
Diastolic blood pressure (mm Hg)				
Pre	63.33	±9.3	62.44	±7.1
Post	61.00	±6.1	57.00	±6.7
Sum of circumferences (cm)				
Pre	530.73	±28.9	519.14	±64.0
Post	534.08	±25.7	524.01	±56.4
Sum of skinfolds (mm)				
Pre	36.33	±15.4	45.56	±20.5
Post	33.78	±14.2	41.22	±16.0
Body fat (%)				
Pre	11.58	±6.9	15.18	±6.6
Post	10.91	±6.8	13.99	±5.5
Lean body mass (kg)				
Pre	68.17	±10.0	60.83	±16.6
Post	69.14	±10.3	65.44	±15.4

* Significantly different ($p \leq 0.05$) from the previous trial for the combined groups.

is that single sets of exercise (the 3DAY group), and even single training days per week (the 1DAY group) in some cases, produced comparable gains to those of previous studies requiring more days of training per week.

The above comparisons and the finding of the present study that the 3DAY group experienced greater percent increases in 1RM for most exercises imply that low-volume strength training, a classification appropriate to both groups in the present study, can produce substantial results. Because the 3DAY group experienced greater gains in strength than the 1DAY group, frequency is probably the more important factor. However, from a dose-response perspective, with the total volume of exercise held constant, spreading the training frequency to 3 doses per week produced superior results.

The gap between gains in the 1DAY and 3DAY groups tended to narrow over time. The 1DAY group experienced ~50% of the improvement observed in the 3DAY group over the first 6 weeks of training. By week 12, the 1DAY group had achieved increases in 1RM that were ~62% of those attained by the 3DAY group. In addition, subjects in the 1DAY group gained ~45–50% of their total percent increase in the first 6 weeks, while the 3DAY group achieved ~53–56% of its total percent increase in the same amount of time. These trends suggest that in a study of longer duration, the difference in improvement between the groups may actually diminish further. Some of the increases in 1RM experienced during the course of the study can probably be attributed to increased neural activation as a result of the high intensity (>80% of 1RM) portions of the training cycle (10, 21). However, the abovementioned greater total increases and more rapid increases in 1RM observed in the 3DAY group must be attributed to a combination of increased neural activation and to the 3DAY groups relatively large increase in body mass (5%) and lean body mass (7.5%). In comparison, the 1DAY group achieved only a 0.5% increase in body mass and a 1.4% increase in lean body mass (Table 4). This supports findings of Baker et al. (2), who suggest that in weight-trained individuals, strength gains are mainly attributable to increases in lean body mass. In our study, the 3-day-per-week frequency of training was a greater stimulus for muscle hypertrophy than the 1-day-per-week frequency. When volume is held constant, the higher frequency could counteract some of the potential muscular atrophy that may take place in a 6-day rest period.

Muscle soreness ratings tended to be relatively low in both groups, with ratings recorded by the 1DAY group (4.8 ± 1.3) slightly higher than those for the 3DAY group (3.3 ± 1.8) for the first 2 weeks. Thereafter, the 1DAY (2.8 ± 1.6) and 3DAY (2.6 ± 1.6) groups recorded very similar ratings. The higher soreness ratings experienced by the 1DAY group during the first 2 weeks of the protocol are possibly the result of greater detraining between sessions. The leveling-off of soreness ratings thereafter may indicate an adaptation to training frequency in terms of muscle atrophy. This process would also explain the greater increase in lean muscle tissue in the 3DAY group and the associated greater percent increases in strength.

An interesting finding was that resting systolic and diastolic blood pressures in both groups tended to decrease, even though all subjects were normotensive and experienced. In fact, the systolic pressure was actually significantly lower posttest for the combined groups (Table 4). One major difference between our paradigm and that of most recreational lifters is the use of alternating upper- and lower-body exercises in a single workout. Most people, including our subjects, found the whole-body routine to be slightly uncomfortable due to the hypotension that results from peripheral blood distribution. The discomfort seems to diminish over time, although beginning lifters might be discouraged. The attenuation of discomfort likely signals some cardiac adaptation that could prove beneficial. This hypotensive discomfort could be virtually eliminated by separating the workout into upper- and lower-body portions performed on different days, but this program would remove some of the advantage of a single day per week of training. These blood pressure results were consistent with others reported in a meta-analysis performed by Kelley (13). The percent decreases in resting systolic blood pressure for the 1DAY group (~5%) and the 3DAY group (~3%) were very comparable to the relative decrease of ~3% observed by Kelley (13). The percent decrease in diastolic blood pressure found in the 1DAY group was ~4%, whereas that of the 3DAY group was ~9%, similar to Kelly's (13) finding of a ~4% decrease.

It should not be overlooked that the 1DAY group experienced large strength gains. In many cases, especially outside competitive athletics, the rate of strength increase may be secondary in importance to the practicality of the training regimen. This is true, for example, in older adults; in this population, gradual increases in strength that can be sustained for long periods of time may be more useful than rapid increases in strength that cannot be sustained because of the required time and resource demands. Also, senior adults may need a greater amount of recovery time, which would be provided by a lower-frequency resistance-training protocol.

The commonly heard adage that ''it's not worth training unless you can train at least 3 days per week'' does not seem to apply to strength training under the conditions of this study. With less travel time to the gym, the average person might find a lower-frequency program of resistance training much more convenient than daily trips to the gym. There are many crucial questions regarding weight-training frequency that need to be answered. In our design we deliberately held the volume of work constant to permit us to compare 2 different training frequencies. In reality, people who train 3 days a week would be able to perform more than 1 set and likely could do about 3 times the volume of work that we permitted. If very rapid strength gains are the goal, then it appears a higher training frequency is needed. Conversely, the gains we observed in experienced recreational lifters were substantial and certainly adequate for recreational and health purposes.

Though only a low-volume comparison, this study suggests that: (a) in recreationally experienced individuals, a 1-day-per-week training protocol produces ~62% of the strength gains observed in a 3-day-per-week protocol, indicating the role for frequency in strength development; (b) from a dose-response perspective, there was a daily contribution of training volume to strength increases because the total volume of exercise was held constant and the reduced-frequency group did almost two-thirds as well as the higher frequency group; (c) low-volume training programs can produce significant increases in strength; (d) all upper-body exercises except the lat pull-down and all lower-body exercises except the leg extension responded better to a higher frequency of training, with leg press and leg curl responding exceptionally well; (e) 12 weeks of low-volume resistance training resulted in trends toward increased lean body mass and decreases in both skinfold thickness and percent body fat; (f) 3-day-per-week training protocol may lead to greater increases in muscle hypertrophy in trained subjects than a 1-day-per-week protocol; and (g) 12 weeks of low-volume resistance training can lead to a significant lowering of systolic blood pressure and a trend toward lower diastolic blood pressure, even in normotensive and experienced subjects.

When attempting to generalize these results to other situations, it should be kept in mind that both training protocols were of a low volume, and that the results may change with implementation of a high-volume training program. Also, the use of a periodization scheme may produce different findings. Future research in these areas would be of great benefit to the resistance training literature.

Practical Applications

In contrast to weightlifters and bodybuilders, many people lifting weights for health and recreation have limited time for resistance training. Studies of reduced-frequency weight-training programs are important not only to the recreational weightlifter, but also in the areas of rehabilitation, space flight, and in-season athletics. All 4 of these groups have limited exercise time. In the rehabilitation setting, patients need the most time-efficient means of recuperating. In-season sports teams can also benefit from low-volume routines, allowing a greater amount of time spent on the practice field or in recuperation. In addition, with the recent increase in frequency of long-duration space flights, interest has focused on time-efficient countermeasures to the loss of muscle strength and bone mass experienced by astronauts exposed to microgravity. Traditionally many exercise leaders have suggested that a frequency of less than 3 training sessions per week was of little benefit. If the results of recent studies such as this one are confirmed, then the general population can be encouraged to weight-train even when only 1 day per week of training is possible. When considering a training protocol design from a dose-response perspective, it is useful to know that a volume overload during only 1 training session can result in ~62% of strength gains observed when the same total dose is spread over 3 days.

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