

■ Effect of Reduced Frequency of Training and Detraining on Lumbar Extension Strength

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To investigate the effect of reduced frequency of training and detraining on lumbar extension strength, 50 subjects (34 men, aged 34 ± 11 yrs; and 16 women, aged 33 ± 11 yrs) were recruited from ongoing strength training programs. Initial training consisted of 10 or 12 weeks of variable resistance lumbar extension strength exercise to volitional fatigue 1, 2, or 3 times a week. After the initial training, subjects reduced the frequency of training to once every 2 weeks ($n = 18$) or once every 4 weeks ($n = 22$) for 12 weeks. Only the frequency of training was changed; the mode, volume, and intensity of exercise remained constant for both reduced frequency of training groups. An additional ten subjects terminated training and acted as controls (detraining group). Isometric lumbar extension strength was evaluated at seven angles through a 72 degree range-of-motion before training, after training, and after reduced frequency of training or detraining. Analysis of variance with repeated measures indicated that lumbar extension strength improved ($P \leq 0.05$) for all groups after the initial 10 or 12 weeks of training. After 12 weeks of reduced training, the once every 2 weeks and once every 4 weeks groups showed no significant reduction in lumbar extension strength at any angle tested, whereas the detraining group demonstrated an average 55% reduction in strength. These findings indicate that isometric lumbar extension strength can be maintained for up to 12 weeks with a reduced frequency of training as low as once every 4 weeks when the intensity and the volume of exercise are maintained. [Key words: lumbar extension strength training, frequency of training, reduced training, detraining, isometric strength]

Medical evidence demonstrates that increasing trunk muscle strength can help prevent and rehabilitate patients who experience low back pain.^{2,4,18,20,22} This is not surprising because low back pain is related to soft tissue damage and insufficient muscle strength.¹ As a result, resistance training for the development of lumbar extension strength has been prescribed for the treatment of low back pain.

Most muscle groups show the greatest strength gains with frequencies of training between 3 and 5 days per week.^{6,18} Fleck and Kraemer⁵ recommend a frequency of 3 times per week for optimal strength training, and this has been shown by Braith et al,³ with the knee extensors. Pollock et al,¹⁹ however, have shown dramatic increases in lumbar extensor strength after 10 weeks of resistance training at a frequency of only one time per week. Furthermore, Graves et al⁷ investigated the effect of training frequency on lumbar extension strength and found that a training frequency of one time per week was as effective for the acquisition of lumbar extension strength as training two or three times per week.

Persons participating in exercise programs occasionally must reduce or stop training. Illness, injury, business commitments, or the culmination of a clinical program can curtail exercise. A concern often arises as to the quantity of exercise needed to maintain strength levels when it becomes necessary to reduce training frequency. Graves et al⁹ investigated the effect of reduced frequency of training on knee extension strength and found that reducing the frequency of exercise from two or three times per week to one time per week allowed the maintenance of muscular strength when the mode, intensity, and duration of exercise were held constant.

Little data exist as to the effect of reduced training on other muscle groups. Because the lumbar musculature responds differently than other muscle groups to low frequencies of training, they may respond differently to reduced frequency of training. To date, there have been no studies investigating the effect of reduced frequency of training on lumbar extension strength. The purpose of this study was to evaluate the effectiveness of varied reduced training frequencies on the maintenance of newly acquired lumbar extension strength, and in addition, to determine the effect of terminating exercise training on lumbar extension strength.

■ Methods

Subjects. Fifty volunteers, 34 men (age = 34 ± 11 yrs; height = 178.3 ± 7.7 cm; weight = 78.0 ± 13.8 kg) and 16 women (age = 33 ± 11 yrs; height = 164.4 ± 6.7 cm; weight = $59. \pm 11.0$ kg) were recruited for this investigation from ongoing

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Table 1. Subject Characteristics (N = 50)

Variable	1×/2Wk Reduced			1×/4Wk Reduced			Detraining		
	M	F	Combined	M	F	Combined	M	F	Combined
N	11	7	18	15	7	22	8	2	10
Age (years)	33.7 ± 10.9	29.9 ± 6.6	32.2 ± 9.4	38.0 ± 11.1	38.0 ± 13.6	38.0 ± 11.6	29.3 ± 11.0	24.0 ± 5.7	28.2 ± 10.1
Height (cm)	179.6 ± 8.4	162.9 ± 4.4	173.1 ± 10.9	178.2 ± 6.1	163.8 ± 6.0	173.6 ± 9.1	176.4 ± 9.7	171.5 ± 14.0	175.4 ± 10.0
Weight (kg)	76.0 ± 14.1	54.3 ± 6.9	67.6 ± 15.9	82.7 ± 13.9	61.1 ± 11.3	76.0 ± 16.4	71.8 ± 11.2	69.6 ± 18.2	71.3 ± 11.7

Values are mean ± SD

ing lumbar extension strength training programs. The duration of these training programs was either 10 or 12 weeks. All subjects were healthy, had no contraindications to exercise and had not participated in isolated lumbar extension exercise prior to the training phase of this study. Written informed consent and a detailed medical history were obtained from all subjects. The program protocol was approved by the Institutional Review Board of the University of Florida College of Medicine.

Strength Testing. Before training, after initial training, and after the reduced or detraining phase of the study, all subjects completed two isometric lumbar extension strength tests. Each isometric test was separated by at least 72 hours to allow a sufficient time for recovery from residual muscle soreness or fatigue that may have been associated with the testing. Prior to each test, subjects completed a 24-hour history questionnaire to help standardize and evaluate recent activities that could potentially influence the results.

The testing procedure measured maximal voluntary isometric torque production at 0, 12, 24, 36, 48, 60, and 72 degrees of lumbar flexion using a MedX[®] (Ocala, FL) lumbar extension machine. This equipment isolates the lumbar extensor muscles by stabilizing the pelvis. Full details of the stabilizing and testing procedures have been presented by Graves et al⁸ and Pollock et al¹⁹ and previous research with this equipment has shown it to be highly reliable ($r = 0.94$ to $r = 0.98$) and specific for the quantification of isometric lumbar extension strength through a 72-degree range of motion.⁸

For each isometric strength test, subjects were seated and secured in the machine and positioned at 72 degrees of lumbar flexion. Subjects were then instructed to extend their back, slowly building up tension for 2–3 seconds while pushing against a back pad that was attached to the movement arm of the machine. Once maximal tension was achieved, subjects were instructed to maintain the contraction for an additional 1–2 seconds before slowly relaxing. A 10-second rest interval was provided between each isometric contraction while the subject was positioned into the next test angle. Subsequent joint angles were tested employing the same procedure.

Strength Training. After the pretraining testing, subjects were randomly assigned to groups that trained from one time a week to three times a week with exercise regimens that consisted of either two sets of dynamic exercise, two sets of isometric exercise, one set of dynamic exercise and one set of isometric exercise, or a single set of dynamic exercise. Isometric exercise was performed at seven angles as described for isometric testing. Dynamic exercise involved variable resistance lumbar extension training through a 72-degree range of motion with a weight load that allowed 8–12 repetitions to volitional

fatigue. When subjects could perform more than 12 repetitions the training load was increased by approximately 5%.

Reduced Training. After the initial testing 40 subjects participated in 12 weeks of reduced training. Subjects were randomly assigned to reduced frequency of training groups that trained once every 2 weeks ($n = 18$) or once every 4 weeks ($n = 22$). During this reduced training period only the frequency of exercise was changed; the volume, mode and intensity of training were held constant for each group. All of the training and reduced training sessions were supervised by experienced laboratory personnel.

Detraining. A third group underwent detraining ($n = 10$) after the initial training period. These subjects participated in no lumbar extension exercise for 12 weeks, and were restricted from any other physical activity that could potentially influence lumbar extension strength. A daily questionnaire was used to screen for such outside activity.

Treatment of the Data. Isometric strength was measured in units of torque (Nm). The second of the two pretraining tests was used as the criterion of before-training strength in accordance with previous research that has shown an initial practice test is required to achieve the most reliable results.⁸ Criteria for the initial training phase and the reduced or detraining phase were obtained from the isometric strength test that yielded the highest average torque value (sum of seven angles). Means and standard deviations were calculated for each angle of measurement, and relative changes in strength were calculated for the before training phase to the initial training phase and for the initial training phase to reduced or detraining phase. Because groups differed with respect to initial strength level, strength values for initial training were compared among groups using analysis of covariance. Pretraining strength values were used as the covariate. To determine whether the ability to maintain strength was effected by the magnitude of strength gained during the training program, a regression analysis was completed to evaluate the relationship between reduced training values and the change in strength from before training to initial training. No significant relationship was observed; and therefore, the reduced training data were evaluated using analysis of variance. Statistical significance was set at $P \leq 0.05$ for all comparisons. All computations were performed using the SAS statistical package.²²

■ Results

Subjects ranged in age from 20 to 64 years. No statistical difference ($P > 0.05$) existed among the groups with

Table 2. Mean Isometric Strength Values (N · m) for Each Test Angle Pretraining, Post-training, and Following Reduced Training or Detraining*

	Angle (Degrees of Lumbar Flexion)						
	0	12	24	36	48	60	72
Reduced Training							
1x/2 WK (n = 18)							
Pretraining	168.1 ± 71.4	201.2 ± 81.0	228.3 ± 91.3	243.7 ± 92.4	258.8 ± 103.4	281.7 ± 117.1	307.6 ± 127.8
Post-training	224.5 ± 95.8	263.7 ± 112.4	281.5 ± 118.5	290.4 ± 121.6	299.3 ± 124.9	316.1 ± 141.9	336.4 ± 146.0
Postreduced	222.5 ± 91.7	257.2 ± 107.9	277.8 ± 113.1	295.5 ± 121.2	299.8 ± 123.0	313.9 ± 134.1	338.5 ± 149.5
†% Change due to reduced	-3.5	-10.4	-3.7	10.9	1.2	-6.4	7.3
1x/4 WK (n = 22)							
Pretraining	208.5 ± 73.4	261.2 ± 81.1	293.3 ± 94.6	316.5 ± 100.6	334.9 ± 108.7	354.4 ± 115.0	390.8 ± 140.9
Post-training	246.5 ± 79.9	301.5 ± 85.4	333.6 ± 96.4	344.9 ± 101.4	367.0 ± 116.1	393.9 ± 127.5	423.9 ± 148.2
Postreduced	229.1 ± 63.4	284.7 ± 68.4	324.1 ± 89.5	347.8 ± 104.2	366.7 ± 113.1	392.4 ± 126.0	422.5 ± 142.1
†% Change due to reduced	-45.8	-41.7	-23.6	10.2	-0.9	-3.8	-4.2
Detraining (n = 10)							
Pretraining	177.2 ± 99.8	268.5 ± 112.7	299.1 ± 116.6	325.6 ± 122.0	338.2 ± 124.2	352.6 ± 132.2	378.5 ± 132.1
Post-training	283.4 ± 65.9	325.8 ± 85.3	348.5 ± 98.7	365.7 ± 119.9	381.2 ± 137.6	395.0 ± 141.8	407.9 ± 151.4
Postdetraining	245.0 ± 63.7	299.4 ± 87.1	325.7 ± 103.9	342.9 ± 121.0	348.9 ± 125.2	363.0 ± 139.8	381.7 ± 153.5
†% Change due to detraining	-36.2	-46.1	-53.8	-56.9	-75.1	-75.5	-89.1

* Strength values are means ± SD.

† % Change expressed as the change of strength relative to the strength gained due to original training.

respect to age, height, or weight (Table 1). Men and women did not differ in their response to training, reduced training, or detraining; therefore, the data were pooled by gender for further analysis.

Mean isometric strength values at each angle of measurement for the before training, initial training, and reduced or detraining phases; data are shown by group in Table 2. All groups showed significant increases in lumbar extension strength from before training to initial training ($P \leq 0.05$). There was no statistical difference among groups with respect to the adjusted initial training strength values. Reduced training showed no significant change for either the 1x/2wk or 1x/4wk group ($P > 0.05$), whereas the detraining group demonstrated a 55% loss of average strength ($P \leq 0.05$).

Pretraining and post-training isometric strength and isometric strength after reduced training and detraining is plotted by angle in Figures 1–3. The 1x/2wk group maintained strength at all angles throughout the range of motion (Figure 1). The 1x/4wk group showed a nonsignificant trend ($P = 0.07$) for a time-by-angle interaction. Evaluation of the data plotted in Figure 2 indicated that subjects were beginning to lose strength in the more extended portion of the range of motion. The 17.5% reduction in average strength (sum of seven angles) for the 1x/4wk group was not significantly different from the 2.2% average strength change demonstrated by the 1x/2wk group. In contrast, the detraining group showed a significant reduction in strength at all angles through the range of motion. This loss was most pronounced in the more flexed portion of the range of motion with an 89% decrease in peak strength (72°). At full extension (0°) the detraining group lost 36% of the strength that was gained during training.

Discussion

Considering that the lumbar extensors show dramatic strength gains at a frequency of 1x/wk,^{7,19} which is not seen in other muscle groups, it was important to investigate reduced frequency for lumbar extension training. The present study has shown that improvements in lumbar extension strength could be maintained for 12 weeks with reduced training frequencies of 1x/2wk or 1x/4wk when the mode, volume and intensity of training were held constant.

Although there is a paucity of data in the literature on reduced strength training, the few studies that do exist

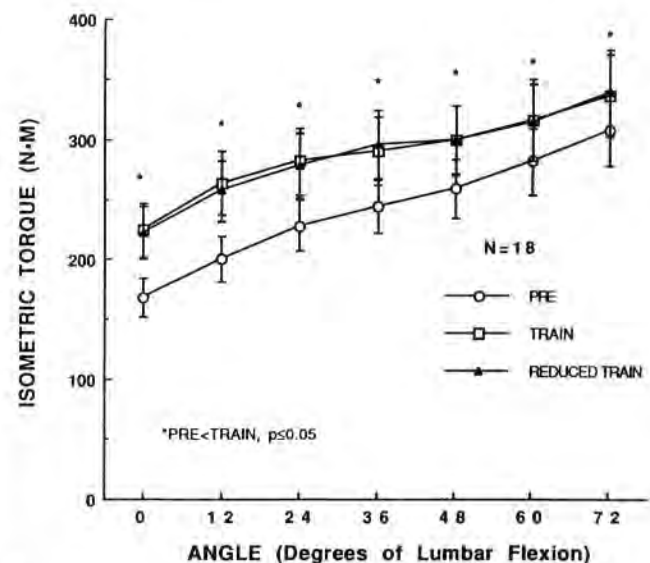


Figure 1. Isometric strength after 12 weeks of training and 12 weeks of reduced training 1x/2wk.

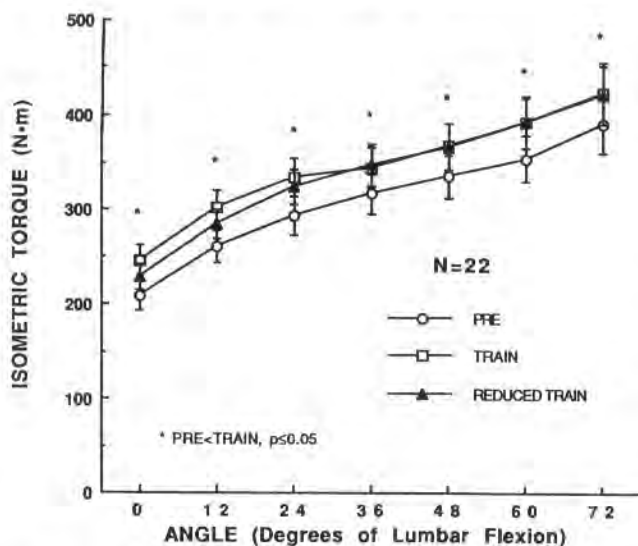


Figure 2. Isometric strength after 12 weeks of training and 12 weeks of reduced training 1x/4wk.

also indicate that training intensity is a key factor for the maintenance of muscular strength. An early investigation by Morehouse¹⁷ demonstrated that the intensity at which muscular contractions were performed during a reduced strength training program had a greater effect on the maintenance of strength than the frequency at which the contractions were performed. Graves et al⁹ showed that reduced training from 3 or 2x/wk to 1x/wk allowed for the maintenance of knee extension strength for up to 12 weeks when the intensity of the training was not changed. Previous research on endurance exercise also indicates that the intensity of training is the key factor in a maintenance program. Aerobic capacity can be maintained during periods of reduced frequency of training as long as the intensity of the exercise is held constant.^{14,15}

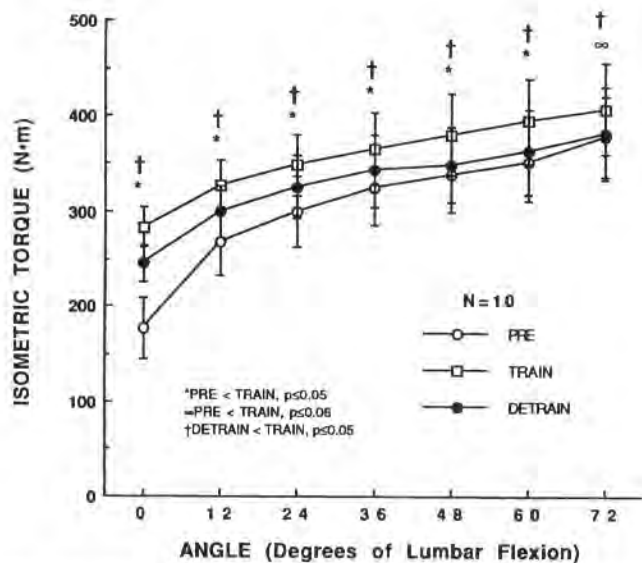


Figure 3. Isometric strength after 12 weeks of training and 12 weeks of detraining.

If the intensity of the exercise is reduced, however, aerobic capacity declines rapidly.¹³

After 12 weeks of reduced training in the present investigation, the 1x/2wk group was able to maintain essentially all of the isometric lumbar extension strength gained during the initial training program. The 1x/4wk group was able to maintain a major portion of the initial strength gained but demonstrated a trend toward losing strength in the more extended portion of the range of motion (24, 12, and 0 degrees of lumbar flexion).

In contrast to the strength maintenance seen with the reduced frequency of training, the detraining group lost 89% of their peak strength gained during training. This is not surprising, because observations of strength loss due to terminated training are well documented. Investigations by Hakkinen et al,^{11,12} Hakkinen and Komi,¹⁰ and Graves et al,⁹ have shown strength decrements of 55–70% after 8–12 weeks of detraining.

Reporting peak or average strength change may not accurately reflect changes at specific points throughout the range of motion. Isometric multiple joint angle testing allowed us to compare the effect of reduced or detraining at specific areas through the full range-of-motion. For example, the trend for strength loss in the 1x/4wk group occurred in the more extended portion of the range (Figure 2), whereas the detraining group showed the greatest relative reduction in the more flexed portion (Figure 3). This evidence demonstrates the importance of accurate, full range of motion testing to properly evaluate training responses.

It is clear that the 1x/4wk group was able to maintain strength through a major portion of the range of motion whereas the detraining group was not. Future research into the effects of continued training at a frequency of 1x/4wk is required to confirm whether the trend toward a reduction in strength becomes significant after 12 weeks. Also, determining the effects of further reduction in frequency to 1x/6wk or 1x/8wk will help establish a threshold frequency at which strength can be maintained.

The ability to maintain lumbar extension strength with a reduced frequency of training should have beneficial implications for clinicians who treat low back pain with rehabilitative exercise. To rehabilitate the patient beyond the point of reduced symptomatology and reduce the risk of future injury, it would be necessary to maintain the strength gained during low back rehabilitation. Many clinical low back programs treat patients for a limited amount of time (usually 8–12 weeks). Once the initial treatment program is completed, patients often eliminate specific low back exercise from their weekly routine. Thus, the results of the current study indicate that muscular strength of the isolated lumbar extensors can be maintained with a frequency of training of 1x/4wk as long as the intensity of the exercise is maintained. Therefore, a patient could return to the clinic for exercise training one time per month to maintain the strength gains made during their clinical program. This may help

clinicians implement rehabilitation programs designed to maintain lumbar extension strength.

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