Isometric Torso Rotation Strength: Effect of Training Frequency on Its Development

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ABSTRACT. DeMichele PL, Pollock ML, Graves JE, Foster DN, Carpenter D, Garzarella L, Brechue W, Fulton M. Isometric torso rotation strength: effect of training frequency on its development. Arch Phys Med Rehabil 1997;78:64-9.

Objective: To examine training frequency's effect on torso rotation muscle strength.

Design: The study followed a pretest-posttest randomized-group design.

Setting: University laboratory.

Patients: Subjects, 33 men (age 30 ± 11yr) and 25 women (age 28 ± 10yr) with no history of low back pain, volunteered to participate in the study and were tested for isometric (IM) torso rotation strength before (T1) and after (T2) 12 weeks of training. Measurements of maximal voluntary IM torso rotation torque (N·m) were made through a 108° range of motion (54°, 36°, 18°, 0°, −18°, −36°, −54°). Subjects were stratified by peak torque at T1, and randomized to a nonexercising control group (C, $n = 10$), or groups that trained once a week (1×/wk, $n = 16$), twice a week (2×/wk, $n = 17$), or three times a week (3×/wk, $n = 15$); and all groups were similar in strength.

Interventions: Training consisted of 8 to 12 repetitions of full range dynamic variable resistance exercise to volitional fatigue, for both left and right rotation.

Main Outcome: To determine the best training frequency for the development of torso rotation strength.

Results: Relative improvements (average increase in strength gained at each angle) for the training groups were 4.9%, 16.3%, and 11.9% for the 1, 2, and 3×/wk groups, respectively. The 1×/wk group did not increase in IM torso rotation strength compared to the control group at any angle. Both the 2 and 3×/wk groups increased their IM torso rotation strength compared to the control group at all but one angle. There were no significant differences in IM torso rotation strength between the groups that trained 2 or 3×/wk. During the training period, the 2 and 3×/wk groups increased their dynamic training load significantly more than the 1×/wk group.

Conclusions: Posttraining dynamic strength was not different between training frequencies of 2 and 3×/wk. Therefore, training the rotary torso muscles 2×/wk is recommended.

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THE SPINE IS THE PRIMARY structure responsible for the maintenance of upright posture of the body and must withstand a complex action system of forces and stresses. Because the ligamentous spine is weak, the extrinsic support provided by the paraspinal and other trunk muscles is critical for maintaining or regaining its health.[1] Evidence shows that the strength of the back muscles is inversely proportional to the incidence of back injury. This is because stronger muscles are more resistant to fatigue, which may prevent injury because they are less likely to lose stability, control, and coordination.[2] Therefore, it is important to determine how to best improve and maintain the strength of these muscles.

Research has shown that different muscle groups are unique in their trainability and adaptability to resistance training.[3] Even so, most experts generally recommend exercise three times a week (3×/wk) for maximal improvement in strength.[3] Several studies evaluating the effects of frequency of training have shown that three or more training sessions per week produced optimal strength improvements in several muscle groups.[4-8] However, when the lumbar extensor muscles were isolated through pelvic stabilization, a training frequency of one time a week (1×/wk) was as effective as two times a week (2×/wk) or 3×/wk for producing strength improvements.[9]

The optimal dynamic training frequency necessary for increasing isometric (IM) strength of the torso musculature has not yet been thoroughly investigated. Since maximal strength is desired for injury prevention or rehabilitation, but too much training could cause injury, an optimal dose needs to be established. Pilot data by Blanton[10] showed that a frequency of training of 1 or 2×/wk may be suficient to train the isolated torso rotation muscles. Because training 3×/wk was not used in the Blanton study, further investigation was necessary to determine the optimal frequency of training required to improve the strength of the torso rotation muscles.[10] The purpose of this study was to examine the differences in strength gained among 1×/wk, 2×/wk, and 3×/wk training groups.

METHODS

Subjects

Ninety-eight subjects volunteered to participate in this study. Descriptive characteristics of the subjects are presented by group in table 1. Subjects were healthy and untrained with respect to torso rotation musculature. Health screening was accomplished through a questionnaire whereby subjects answered questions concerning their history of cardiovascular disease, significant orthopedic problems associated with the trunk and spine, and other medical contraindications to strenuous exercise. The study was approved by our college of medicine's Institutional Review Board. All subjects signed an informed consent form.

The study followed a pretest-posttest randomized-groups design. All IM strength measurements were made using a MedX[a] torso rotation testing and rehabilitative exercise machine. The pretest (T1) consisted first of three IM testing sessions to determine IM strength. The first IM test was considered a practice

Table 1: Subject Characteristics of Rotary Torso Training and Control Groups

Variable	Control	1×/Wk	2×/Wk	3×/Wk
N				
Men	7	8	9	9
Women	3	8	8	6
Total	10	16	17	15
Age	34.8 ± 10.4	28.6 ± 8.8	26.7 ± 9.9	31.1 ± 11.3
Height (cm)	173.0 ± 7.5	171.9 ± 9.0	175.2 ± 9.8	171.9 ± 8.1
Weight (kg)	80.0 ± 14.6	71.9 ± 13.1	75.1 ± 14.8	73.5 ± 13.3

There were no significant differences among the groups' characteristics ($p > .05$).

session, so torque measurements from this test were not included in the data analysis. Following T1, subjects were randomized to one of four groups: control, 1×/wk, 2×/wk, or 3×/wk. IM testing was followed by either 12 weeks of no torso musculature training (for the control group) or dynamic exercise training (for the 3 training groups) on the same MedX rotary torso machine used for testing. Finally, two IM posttests were performed to determine the change in IM strength after the 12-week training period.

Isometric Testing

Subjects were seated in the rotary torso machine and secured tightly by restraint pads positioned at the chest, thighs, and hips. The unique configuration of the restraint pads prevented any forward, backward, or lateral movement of the hips, legs, and shoulders, thus allowing for the isolation of the torso rotation muscles. Figure 1 shows both the restraint system and how the machine moves to accommodate torso rotation through the full range of motion (ROM). Maximal IM torso rotation strength was measured at seven standard positions throughout a full 108° ROM. This was done for both left and right rotation. Measurements of torque (N·m) were taken at −54°, −36°, −18°, 0°, 18°, 36°, and 54° of torso rotation. The initial direction of testing was randomized and balanced among subjects and held constant across pretraining and posttraining strength tests.

Using a "reverse" angle test protocol, testing began at the shortest muscle length (the weakest angle), and proceeded to the fully stretched position. The reverse angle protocol was employed instead of the forward angle protocol (which tests the stronger angles first) to minimize fatigue due to testing order.[11] This method has been shown to have high test-retest reliability ($r = .83$ to .99) from −54° to 54° of torso rotation, in subjects of the same age range.[11] Subjects were instructed to gradually build up tension against the machine's movement arm over a 3- to 4-second period by slowly exhaling while attempting to rotate their torso in the desired direction against the stabilized pads. All subjects were encouraged to give an "all-out" effort and were required to agree to adhere strictly to their assigned training frequency, or they would have had to drop out of the study. Subjects were given approximately 10 seconds of rest between each angle while the machine was rotated to the next angle. Subjects were then cued to again gradually exert force against the stabilizing pads. When maximum torque was achieved, subjects were encouraged to maintain their effort for an additional 1 to 2 seconds before gradually relaxing the torso rotation muscles. This procedure continued until all the angles for one side were tested, taking approximately $1\frac{1}{2}$ to 2 minutes. After a 5-minute rest period, the test was repeated in the opposite direction, so the total testing time was 8 to 9 minutes (including the 5-minute break).

After the completion of the first test session, subjects performed two additional tests on separate days a minimum of 72 hours. On subsequent days IM tests were repeated following the same procedure, and the direction of testing was alternated between sides. The initial direction of testing was randomized and balanced among subjects and held constant across pretraining and posttraining strength tests. The first test session was considered to be a practice session because previous research has demonstrated that one practice test is usually required before the most reliable measurements of maximal IM strength can be obtained.[12]

After the initial strength tests, the subjects were ranked according to their peak isometric strength and assigned to one of three training groups or a nonexercising control group, using a stratified randomization technique. More subjects were assigned to the training groups because the training groups were expected to have more dropouts.

Training

Subjects were randomized to one of the following three training groups, which varied in frequency: 1×/wk, 2×/wk, or 3×/wk. The same torso rotation apparatus used for testing was used for training. Each training session consisted of performing one set (8 to 12 repetitions) of dynamic variable resistance exercise

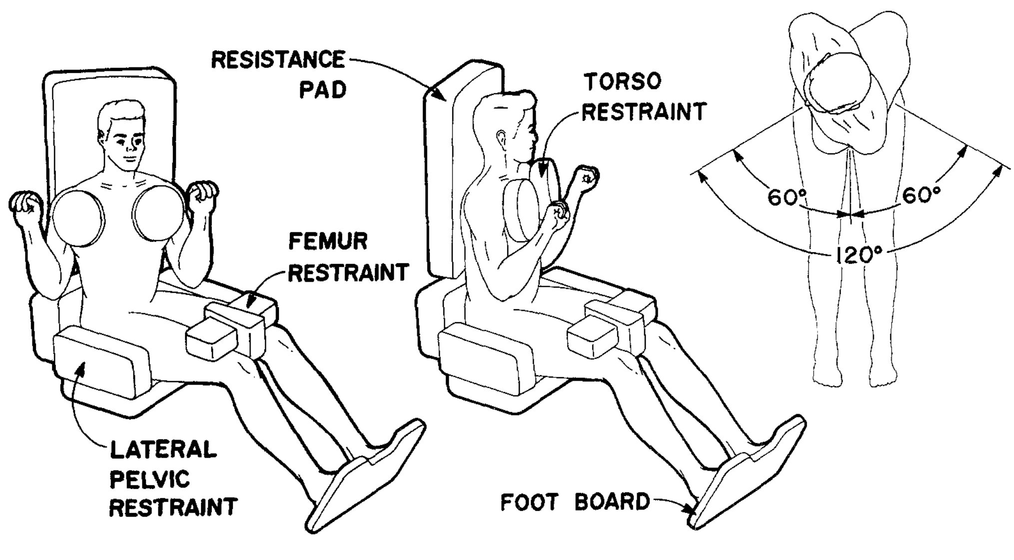

Fig 1. The rotary torso machine's restraint system and range of motion. Although the machine has a full range of motion of 120°, subjects were tested through 108°. (Reproduced with permission from the MedX Corporation.[a])

Table 2: Dropout Rate per Group to Rotary Torso Testing and Training

Group	Reason for Dropping Out		
	Unrelated	Discomfort	Total
Control	4	0	4
1×/wk	4	1	5
2×/wk	7	1	8
3×/wk	15	4	19

rotating from right to left and left to right (one set each) to volitional fatigue, using the following protocol. Subjects were first seated in the rotary torso machine, and secured in the same manner as that described for testing. Once secured, each subject was allowed a standard warm-up consisting of 3 to 6 repetitions of slow and controlled dynamic variable resistance rotary torso exercise, through the subject's full ROM, with a load that was 50% of the prescribed training weight.

The initial direction of training (rotation from right to left or from left to right) was randomized from one training session to the next. When the training resistance was engaged, the subject was cued to contract the torso musculature and rotate through their full ROM. The concentric phase of the contraction lasted for 3 seconds, followed by a pause of 1 second at the fully contracted position, and then an eccentric contraction was performed as the subject returned to the starting position for 4 seconds. The cadence was monitored and visual feedback was provided on a computer monitor that was interfaced with the movement arm of the machine. After each training session, the resistance, number of repetitions, and total exercise time in seconds was recorded for each subject. Certified laboratory technicians supervised and encouraged the subjects to perform repetitions in a slow, controlled manner until they reached volitional muscular fatigue.

The initial training load was set at 60% of the peak IM torque achieved by each subject during pretesting. When 12 or more repetitions were completed in a set, the resistance for the next training session was increased by 5ft-lbs. This was done to set a resistance that would allow 8 to 12 repetitions to be performed to volitional muscular fatigue (until the subject could not repeat the contration through the full range of motion with good form). If the repetitions exceeded 15, the resistance was increased by 10ft-lbs. A 5-minute rest was allowed before training the opposite side.

Treatment of the Data

Since it had been shown that one practice testing trial was necessary to attain the highest reliability, pretraining tests 2 and 3 were averaged and used as the criterion measures of pretraining IM strength.[11] The highest value posttesting for tests 1 and 2 was used to determine the change in IM strength after the 12-week training period. Means and standard deviations were calculated for the pretraining and posttraining tests at each angle measured. The dynamic weight training data were averaged for weeks 1 and 2, 6 and 7, and 11 and 12 and used as the criterion measures for dynamic strength gains.

Analysis of variance (ANOVA) with repeated measures was used to compare differences in right and left side rotation with respect to IM strength. Since these values were similar ($p >$ .05) the data were pooled for further analysis. Both the pretraining and posttraining criterion values were calculated from the mean of the right and left criterion tests. Although the groups were not different in strength initially, the data were analyzed using an analysis of covariance (ANCOVA) in an effort to be conservative. The following preplanned comparisons were made: (1) changes in isometric strength for each group were compared relative to the control group; (2) changes in isometric strength and changes in training weight were compared among the three training groups. In all cases, pretraining criterion measures (isometric strength and training weight) were used as covariates. ANOVA and ANCOVA were performed using the SAS general linear model (GLM) procedure (SAS Users Guides, 1985).[13] Statistical significance was accepted at $p \leq$ .05.

RESULTS

Subjects

Fifty-eight (33 men and 25 women) of the 98 volunteers (59.2%) that entered the study completed all required testing and training. The number of subjects randomized to each group that successfully completed pretesting, training, and posttesting were as follows: 1×/wk, n = 16; 2×/wk, n = 17; 3×/wk, n = 15; control, n = 10. Mean values and standard deviations for subject characteristics are listed by gender in table 1. There were no significant differences ($p >$ .05) among groups for age, height, and weight.

Forty subjects elected not to complete all phases of the study (table 2). Twenty-one subjects that dropped out of the study gave no reason why, or explained conflicting work and/or school commitments. Twelve of these subjects cited specific reasons for dropping out, including: virus, moved from area, and injuries unrelated to training. Seven subjects suffered from minor testing- or training-related back discomfort and were unwilling to continue the study. One of these subjects had discomfort during the initial testing because of a preexisting condition and never began training, and 4 had been training 3×/wk, 1 2×/wk, and 1 1×/wk. Discomfort began at various points in the 12-week training protocol; however, it is important to note that their problems were not serious, and none required extensive medical care.

Frequency of Training

Mean values and standard deviations of pretraining and posttraining IM torque for each of the angles tested are presented for all three experimental groups in table 3.

Table 3: Effects of 12 Weeks of Torso Rotation Training on IM Torque (N·m)

Group	Control	Training Frequency Per Week		
		1×/wk	2×/wk	3×/wk
N	10	16	17	15
Degrees				
−54°				
Pre	29.5 ± 14.2	26.0 ± 13.3	31.1 ± 22.0	26.8 ± 12.8
Post	29.0 ± 12.4	32.2 ± 16.0	40.0 ± 20.6	34.6 ± 15.8
−36°				
Pre	54.8 ± 22.2	45.7 ± 16.4	51.5 ± 29.9	50.6 ± 18.6
Post	54.9 ± 21.8	52.3 ± 21.0	63.2 ± 29.5	59.6 ± 22.1
−18°				
Pre	78.7 ± 28.8	66.3 ± 23.8	73.7 ± 39.6	74.5 ± 27.5
Post	76.3 ± 26.0	71.8 ± 25.1	85.8 ± 38.3	82.7 ± 28.7
0°				
Pre	97.7 ± 32.4	83.3 ± 29.2	92.3 ± 45.7	95.0 ± 33.5
Post	94.3 ± 28.2	87.3 ± 29.7	107.9 ± 48.9	103.0 ± 32.4
18°				
Pre	112.0 ± 37.8	97.1 ± 34.9	105.3 ± 47.9	110.6 ± 40.2
Post	109.2 ± 35.2	99.7 ± 32.4	122.8 ± 54.0	120.6 ± 39.1
36°				
Pre	119.9 ± 38.7	107.0 ± 37.9	116.9 ± 51.7	121.3 ± 44.6
Post	118.8 ± 39.2	108.0 ± 34.3	134.8 ± 59.7	134.6 ± 42.9
54°				
Pre	124.1 ± 37.8	114.1 ± 40.2	124.3 ± 53.5	127.2 ± 49.3
Post	122.9 ± 37.9	114.4 ± 39.4	137.8 ± 56.7	143.1 ± 47.2

Data represent mean values ± standard deviations.

Table 4: Adjusted Posttraining Mean Torque Values (N · m) for Torso Rotation IM Strength Improvements After 12 Weeks of Torso Rotational Strength Training

		Training Frequency Per Week		
	Control	1×/wk	2×/wk	3×/wk
N	10	16	17	15
Degrees				
−54°	28.0	34.2	37.6*	35.9*
−36°	50.4	56.7	62.0*	59.3*
−18°	70.8	77.8	84.9‡	81.1*
0°	88.5	94.9	106.7†	99.7
18°	103.0	107.8	123.1‡	115.8*
36°	114.8	116.7	133.7‡	129.2‡
54°	121.1	122.2	135.8‡	138.3‡

* Significance compared to Control, $p < .05$.
† Significance compared to 1×/wk, $p < .05$.
‡ Significance compared to Control and 1×/wk, $p < .05$.

Adjusted posttraining IM torques for the three groups that trained dynamically and the control group are presented in table 4, and a graphic representation can be found in figure 2. ANCOVA revealed that the 2×/wk and 3×/wk groups improved ($p \leq .05$) in ability to generate IM torque using the torso rotation musculature at −54°, −36°, −18°, 18°, 36°, and 54° compared to the control group. The 3×/wk group was stronger at 36° and 54° compared to the 1×/wk group. The 2×/wk group was stronger ($p \leq .05$) than the 1×/wk group at −18°, 0°, 18°, 36°, and 54°. The control group showed no significant increase in IM torque at any angle tested ($p > .05$). When groups were compared among themselves, the 1×/wk group did not differ ($p > .05$) from the control group and the 2×/wk group did not differ ($p > .05$) from the 3×/wk group in IM torso rotation strength at any angles tested. Thus, the 2×/wk and 3×/wk groups were similar in terms of the magnitude of strength gained. The relative improvements in strength, or the average increase in strength at each angle, for the training groups were 4.9% for the 1×/wk group, 16.3% for the 2×/wk group, and 11.9% for the 3×/wk group.

A comparison of the weight lifted per training session, averaged for weeks 1 and 2, 6 and 7, and 11 and 12 for the three exercise groups are shown in table 5. The covariance comparing the adjusted means for initial and final training weights found the 2×/wk and 3×/wk groups to increase training weight more

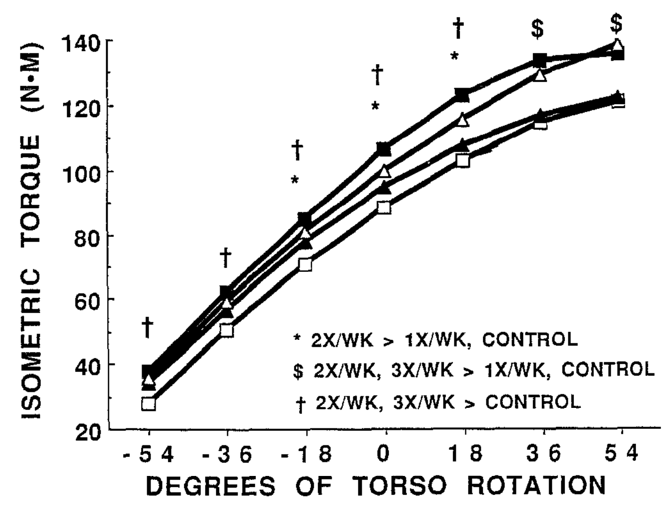

Fig 2. Adjusted posttraining mean torque values (N · m) for torso rotation IM strength improvements for all groups (□, control; ▲, 1×/wk; ■, 2×/wk; △, 3×/wk) from −54° to 54° of torso rotation after 12 weeks of torso rotational strength training.

Table 5: Groups' Initial, Midpoint, and Final Training Weights

	Mean Training Resistance (kg)			
Group	Initial (I)	Middle	Final (F)	Change (I-F)
1×/wk	38.55	40.59	46.22	7.67
2×/wk	40.50	48.64	55.47	14.97*
3×/wk	40.50	49.68	54.39	13.88*

* 2×/wk, 3×/wk > 1×/wk, $p < .05$.

than the 1×/wk group (table 5). There was no difference in training weight increases ($p > .05$) between the 2×/wk and 3×/wk training groups.

DISCUSSION

Training Frequency

The results of the present investigation indicate that training either 2×/wk or 3×/wk provided a significant increase in torso rotation strength compared to the control and 1×/wk groups. Further, there was no significant difference in IM or dynamic torso rotation strength between the 2×/wk and 3×/wk groups.

Table 6 summarizes the results from other resistance training studies comparing frequency of training using a variety of muscle groups. Many researchers have found training frequencies of 3×/wk or higher to provide larger strength gains than lower frequencies for most limb muscle groups.[4,5,8,14,15] Using the bench press exercise, Hunter[6] found that 4×/wk training gained more strength when performed over a period of 7 weeks. Gillam[5] also using the bench press exercise, found 5×/wk to produce increases in strength superior to the 1, 2, 3, and 4×/wk training protocols that were conducted over a 9-week period. He also found that 3 and 4×/wk training gave similar results and were significantly ($p \leq .05$) better than 1×/wk and 2×/wk. The results from Henderson[4] were in agreement with Gilliam[5] in that a 3×/wk training frequency was found to produce significantly larger strength improvements than 2×/wk after a 6-week training period. In contrast, Berger's[16] bench press study found that training 2×/wk or 3×/wk for 12 weeks produced similar strength gains.

Braith et al,[7] in two different studies using bilateral knee extension showed that a 3×/wk training frequency was superior to 2×/wk, as a training mode, in producing strength improvements over a 10- and 18-week training period. Using the full knee bend (squat) strength exercise, Barham[14] found that a training frequency of 5×/wk was equal to 3×/wk, and both were shown to be superior to the 2×/wk frequency of strength training.

Leggett et al[8] and DeFilippo[17] found that training frequencies of 2×/wk and 3×/wk were superior to 1×/2wk and 1×/wk for developing cervical rotation strength over a 12-week training period. In these same studies, the 3×/wk group improved more than the 2×/wk group. Over a 12-week training period using a cervical extension mode of exercise, Pollock et al[18] showed that 2×/wk could produce larger improvements in strength than 1×/wk. Since a frequency greater than 2×/wk of training was not used, no inferences can be made in this regard.

In an investigation of lumbar extension strength, Graves et al[19] found that training 1×/wk could produce strength improvements significantly greater than training 1×/2wk and equal to those who exercised 2×/wk or 3×/wk, over a 12- and 20-week training period (table 6). Thus, it is clear that the same frequency of resistance training may not be optimal for every muscle group. The arms (chest) and legs may need a greater frequency of training than the trunk (lumbar) area.

Table 6: Results from Studies Comparing Frequency of Training Using Resistance Exercise

Study	N	Sex	Exercise	Days/wk	Duration	Sets Reps	Increase %
Berger[16]	NA	NA	Bench press	2, 3	12wk	1 × 10 RM	NA[a]
Henderson[4]	117	M	Bench press	2, 3	6wk	2 × 9 RM	2×/wk = 12.78lbs
						3 × 6 RM	3×/wk = 19.21lbs[b]
Hunter[6]	24	M	Bench press	3	7wk	3 × 10	M = 11.9%
							F = 19.5%
	22	F		4	7wk	2 × 10	M = 16.7%[c]
							F = 33.3%[c]
Gillam[5]	68	M	Bench press	1	9wk	18 sets × 1 MR	1×/wk = 19.5%
				2			2×/wk = 24.2%
				3			3×/wk = 32.27%[d]
				4			4×/wk = 29.02%
				5			5×/wk = 40.71%[d]
Barham[14]	90	M	Full-knee bends	5, 3, 2	6wk	3 × 5	NA[e]
Braith et al[7]	28	M	Bilateral knee extension	2, 3	10wk	1 × 7-10	2×/wk = 13.5%
	33	F					3×/wk = 21.2%[f]
	31	M		2, 3	18wk	1 × 7-10	2×/wk = 20.9%
	25	F					3×/wk = 28.4%[f]
Graves et al[19]	72	M	Lumbar extension	1×/2wk	12, 20wk	1 × 8-12	1×/2wk = 26.6%
				1, 2, 3			1×/wk = 38.9%[g]
	42	F					2×/wk = 41.4%[g]
							3×/wk = 37.2%[g]
Pollock et al[18]	50	M	Cervical extension	1	12wk	1 × 8-12	1×/wk = 8.7%
	28	F		2			2×/wk = 32.8%[h]
Leggett et al[8]	54	M	Cervical rotation	1×/2wk	12wk	1 × 8-20	1×/2wk = 9.0%
	26	F		1, 2, 3			1×/wk = 15.9%
							2×/wk = 24.3%[i]
							3×/wk = 38.4%[i]
Blanton[10]	47	M	Torso rotation	1, 2	12wk	1 × 8-12	1×/wk = 17.4%[j]
	34	F					2×/wk = 21.8%[j]
Feinberg[20]	33	M	Torso rotation	1, 2, 3	12wk	1 × 11-15	1×/wk = 4.9%
							2×/wk = 16.3%[k]
	25	F					3×/wk = 11.9%[k]

Abbreviations: M, male; F, female; NA, data not available; MR, maximal repetition.
[a] $p > .05$; 2 = 3×/wk. [b] $p < .05$; 3×/wk > 2×/wk. [c] $p < .01$; 4×/wk > 3×/wk. [d] $p < .05$; 5×/wk > 1-4×/wk, 3, 5×/wk > 1, 2×/wk. [e] 5×/wk = 3×/wk, 5, 3×/wk > 2×/wk. [f] $p < .01$; 3×/wk > 2×/wk. [g] $p < .05$; 1, 2, 3×/wk > 1×/2wk. [h] $p < .05$; 2×/wk > 1×/wk. [i] $p < .05$; 2, 3×/wk > 1×/wk, 1×/2wk; 3×/wk > 2×/wk. [j] $p < .05$; 1 = 2×/wk. [k] $p < .01$; 2, 3×/wk > 1 ×/wk.

Comparison to a Previous Rotary Torso Study

Our finding that the group training dynamically 1×/wk for 12 weeks did not significantly improve IM torso rotational strength was surprising and in contrast to Blanton,[10] who found an average increase of 17.4% in IM torso rotation strength. Blanton's study did not include a 3×/wk training group, but his 2×/wk group did not improve strength more than the 1×/wk training group ($p > .05$) (table 6). These results are difficult to evaluate because the control group also increased in strength (8.9%). It is unusual for a control group that did not exercise to improve in strength. Whether a methodological problem existed in the testing procedure is not known. Whatever caused the increase in strength of the control group could have accounted for some of the strength improvements in his 1×/wk (17.4%) and 2×/wk (21.8%) groups. If so, strength increases may have been much closer to the 1×/wk (4.9%) and 2×/wk (16.3%) found in the present study. This study used 12 weeks of training because that is the standard in this laboratory, and most strength training studies in the literature are 8 to 12 weeks in duration. Also, most rehabilitation programs terminate within 8 to 12 weeks. As table 5 indicates, large increases in strength were developed after 6 weeks.

Dropouts

In our study, the dropout rate was found to be inversely related to training frequency. Of the randomized subjects that did not complete their testing and training, 15 were from the 3×/wk group, 7 were from the 2×/wk group, and only 4 dropped from both the 1×/wk and control groups. Thus, it seems that an increased frequency may cause subjects to be more likely to decide to drop out. Of the 88 subjects (10 of the original 98 volunteers did not finish pretesting) that were randomized, 58 (65.9%) completed this study. Blanton[10] found that of 74 subjects who agreed to be randomized into training and control groups, 48 (64.9%) actually completed all testing and training. There was not a frequency effect related to dropping out of training, but no 3×/wk frequency group was included. Graves et al[19] reported a similar total dropout rate as Blanton[10] and our study. He found 114 of 170 subjects (67.1%) completed all testing and training procedures related to the lumbar extension exercise. They did not report a breakdown of dropouts for their various frequency of training groups.

Other resistance training frequency studies have shown better adherence to their training protocols. DeFilippo et al[17] found that 86 of 92 subjects adhered to a 12-week cervical rotation training study (93.5%). Gillam[5] showed that 68 of the 75 (90.7%) original subjects who trained with the bench press exercise completed all training and testing. He stated that no subject complained of chronic fatigue or injury related to the training or voluntarily withdrew from the study. The subjects that were eliminated from Gillam's[5] study either were unable to make up exercise sessions that they missed or failed to perform for two consecutive exercise sessions. Most studies did not report dropout data, so these could not be compared.

Subjects in the present study gave many different reasons for not completing all phases of the study. Twelve subjects cited specific reasons for dropping out that were probably unavoidable and not related to the training frequency. They included: virus, moving from the area, and injuries unrelated to training. However, the rigors of testing or training could have affected the rest of the 28 dropouts. Twenty-one subjects that dropped out of the study gave no reason why, or found work and/or school commitments keeping them too busy. A few subjects commented that the machine was uncomfortable, and that they did not like the way the torso restraint pressed in on their chest. Finally, rotating the torso under load in the longitudinal plane may be more difficult to become accustomed to than other resistance exercises.

The possibility existed that certain subjects would be more sensitive to perceived fatigue or discomfort either because of their gender or age, or because they were students. However, with a total of 19 men and 21 women dropping out, there was clearly no gender effect. Further, there was no difference in the dropout rate between the older or younger subjects. Finally, as far as the notion that students might be more immature or irresponsible than working people, it was found that 32 of the original 46 student subjects completed the study. Thus, their adherence was 69.6%, which was higher than the overall adherence of 59.2%.

A total of seven subjects suffered from minor testing- or training-related back discomfort and were unwilling to continue the study. Of these seven subjects: one strained his back, another developed a middle back aggravation, a third began having back spasms in the thoracic area, and the remaining four experienced orthopedic discomfort of the low back. One of these subjects had discomfort during the initial testing due to a preexisting condition and never began training. The rest of the subjects' discomfort began at various points in the 12-week training protocol: 4 in the 3×/wk, 1 in the 2×/wk, and 1 in the 1×/wk training groups. It is likely that training frequency significantly affected the dropout rate of the subjects experiencing discomfort during training, since most were in the 3×/wk frequency group. Also, even the individuals in the 3×/wk training group that did successfully complete the study complained more about minor muscle soreness and fatigue than those in the other two training groups.

The results of this investigation demonstrated that the 2×/wk training frequency obtained better adherence and equal strength gains compared to the 3×/wk group. Therefore, a training frequency of 2×/wk is recommended for training the torso rotational muscles. These findings should be clinically relevant for rehabilitation or preventative programs that employ torso rotation training, since a training protocol of 2×/wk is more efficient and cost effective than training 3×/wk, and would be easier for patients to comply with.

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