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Effects of Exercise Only and Exercise Plus Electrical Stimulation on Ratings of Low Back Pain and Fatigue

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ABSTRACT

Westcott W, George VP, La Rosa Loud R, Whitehead S, Young S, Vallier S. Effects of Exercise Only and Exercise Plus Electrical Stimulation on Ratings of Low Back Pain and Fatigue. **JEPonline** 2016;19(2):17-26. The purpose of this study was to compare the effects of exercise alone and exercise plus electrical stimulation on ratings of low back pain, low back fatigue, low back strength, body composition (%fat, lean weight, fat weight), and resting blood pressure over a 9-wk training period. All of the study participants (n=77, mean age = 64.8 yrs) completed 2 training sessions·wk^{-1} consisting of 9 resistance machine exercises and 18 min of aerobic activity. About half of the subjects (n=42) also performed 4 electrical stimulations each week (averaging 61 min·session^{-1}). Subjects in the exercise only group attained a significant ($P<0.05$) improvement in low back pain and low back fatigue. Subjects in the exercise plus electrical stimulation group attained a significant ($P<0.05$) improvement in low back pain, low back fatigue, and low back muscle strength. These findings indicate that a basic program of strength and endurance exercise is effective in reducing low back pain and low back fatigue, and that supplemental electrical stimulation increases low back strength.

Key Words: Low Back Pain, Low Back Fatigue, Low Back Strength, Electrical Stimulation

INTRODUCTION

Previous research has indicated that appropriate resistance exercise can be an effective means for strengthening the lumbar spine muscles and for reducing low back pain (4,10,24). The most productive exercise for progressively increasing low back strength appears to be full range (approximately 75°) trunk extension performed with about 75% of maximum resistance for 8 to 12 controlled repetitions (10,14,17). There is also evidence that lumbar and pelvic stabilization are important factors for low back strengthening and rehabilitation (16,17,25).

While multidisciplinary programs have produced improvements in low back strength and pain levels (21), the key components for successful intervention appear to be lumbar extension resistance exercise performed with relatively high workload, low volume, and low frequency (14,24,26). In fact, research by Steele et al. (26) suggests that relatively high resistance, low volume, and low frequency strength training may actually promote healing or regeneration of intervertebral discs.

Several studies on resistance exercise have demonstrated that relatively high load, low volume, and low frequency strength training results in significant strength gain and muscle development with adults and older adults (3,13,23,31). However, the tissue microtrauma caused by high-intensity resistance training requires a major metabolic response to facilitate muscle remodeling processes and resultant strength development. Research reveals that resting energy expenditure increases between 5% and 9% for up to 3 days following a high-effort bout of resistance training (11,12).

Exercise physiologists have explored various means for enhancing muscle remodeling and strength development during the recovery period between workouts. Several studies have shown significantly greater strength gains when exercisers consume supplemental protein right after working out to change an otherwise negative post-training protein balance to a positive post-training protein balance (1,6,8,20,22,30). Research has also revealed that muscle recovery and strength development may be enhanced through application of electrical stimulation between training sessions (7,9,15,19,27). In two of our previous studies, the exercise plus electrical stimulation groups attained significantly greater gains in muscle strength and significantly greater reductions in muscle fatigue than the exercise only groups (28).

A 2012 study examined changes in muscle strength and low back fatigue after 8 wks of total body resistance exercise with and without electrical stimulation (29). Although the exercise plus electrical stimulation group attained greater improvements in muscle strength and muscle fatigue than the exercise only group, the differences were not statistically significant. Based on the results of our previous research, we conducted a more comprehensive study comparing the effects of exercise alone and exercise plus electrical stimulation on low back pain, low back fatigue, low back strength, body composition, and resting blood pressure. We hypothesized that the exercisers who received supplemental electrical stimulation would experience significantly greater reductions in low back pain and low back fatigue, as well as significantly greater increases in low back muscle strength. We further hypothesized that

these exercisers would experience significantly greater improvements in body composition and resting blood pressure.

METHODS

Subjects

The Quincy College Institutional Review Board approved this study, which was conducted over a 9-wk period during the summer of 2015. The subjects consisted of 77 men and women (mean age 64.8 yrs) who reported conditions of both low back pain and low back fatigue. The exercise only group (n=35, mean age 64.2 yrs) performed the prescribed strength and endurance training program without using electrical stimulation. The exercise plus electrical stimulation group (n=42, mean age 65.3 yrs) performed the same strength and endurance training program with electrical stimulation. Characteristics for the subjects in the two study groups are presented in Table 1.

Table 1. Initial Subject Characteristics for the Two Study Groups.

	Exercise Only Group	Exercise Plus Electrical Stimulation Group
Subjects	35	42
Age (yrs)	64.2 ± 12.9	65.3 ± 11.2
Low Back Pain (1-9)	5.77 ± 1.54	6.02 ± 2.05
Low Back Fatigue (1-9)	5.53 ± 1.56	5.48 ± 1.94
Body Weight (lbs)	178.0 ± 50.2	176.0 ± 44.1
Percent Fat (%)	26.9 ± 5.87	24.9 ± 6.94
Fat Weight (lbs)	46.8 ± 16.4	44.9 ± 20.3
Lean Weight (lbs)	129.0 ± 33.9	131.0 ± 31.1
Low Back Strength (lbs)	47.9 ± 29.3	54.4 ± 37.1
Systolic Blood Pressure (mmHg)	127 ± 18.50	126 ± 14.20
Diastolic Blood Pressure (mmHg)	75.8 ± 11.19	75.3 ± 9.25

Procedures

The subjects trained in small classes (3 to 6 participants each) under careful supervision of nationally certified exercise instructors (1 to 2 teachers per class) at the Quincy College Exercise Research Center. Classes met for 60 min, twice a week for a period of 9 wks. During each class, the subjects performed 1 set of 9 resistance machine exercises and 18 min of aerobic activity. Based on our previous research, we incorporated a combined training protocol in which the subjects performed 3 resistance exercises for the leg muscles followed by 6-min of aerobic activity, 3 resistance exercises for the upper body muscles followed by 6-

min of aerobic activity, and 3 resistance exercises for the core muscles followed by 6-min of aerobic activity (see Table 2).

Table 2. Exercise Sequence and Targeted Muscles for Both Study Groups.

Exercise Machine	Muscle Group	Reps/Time
Leg Extension	Quadriceps	8-12 Reps
Leg Curl	Hamstrings	8-12 Reps
Leg Press	Quadriceps, Hamstrings, Gluteals	8-12 Reps
Cycle or Treadmill	Cardiorespiratory System	6 Min
Chest Press	Pectoralis Major, Anterior Deltoids, Triceps	8-12 Reps
Pull Down	Latissimus Dorsi, Posterior Deltoids, Biceps	8-12 Reps
Shoulder Press	Medial Deltoids, Triceps	8-12 Reps
Cycle or Treadmill	Cardiorespiratory System	6 Min
Abdominal	Rectus Abdominis	8-12 Reps
Low Back	Erector Spinae	8-12 Reps
Rotary Torso	Internal Obliques, External Obliques	8-12 Reps
Cycle or Treadmill	Cardiorespiratory System	6 Min

The resistance exercises were performed with a weight load that could be completed between 8 and 12 repetitions (approximately 70% to 80% of maximum resistance). When 12 repetitions were completed with proper technique, the resistance was increased by about 5%. Exercise repetitions were performed with a moderate movement speed (3-sec concentric muscle action and 3-sec eccentric muscle action) through a full-range of joint function.

The aerobic activity was performed in an interval training manner, with 30 sec of higher-effort exercise alternated with 30 sec of lower-effort exercise during each 6-min cardio bout. Heart rates were maintained at approximately 65% to 80% of maximum throughout the aerobic activity segments.

In addition to the exercise program, 42 subjects applied supplemental electrical stimulation to their low back muscles throughout the 9-wk study period. All of the subjects received a personal Marc Pro Plus^{TM} device, and were trained to self-administer approximately 1 hr of electrical stimulation 4 $d \cdot wk^{-1}$ in their homes.

Statistical Analyses

Assessments of low back pain, low back fatigue, low back strength, percent fat, lean weight, fat weight, and resting blood pressure were conducted during the first and final week of the

study. Low back pain and low back fatigue were evaluated on a 9-point rating scale with anchors of 1 (never experience) and 9 (experience essentially all day). Low back strength was assessed by an isometric test of lumbar extension force using the Microfit system. Body composition measures (percent fat, lean weight, and fat weight) were assessed by computerized ultrasound technology (SomaTech), and resting blood pressure readings were obtained with a calibrated sphygmomanometer and stethoscope. All of the assessments were conducted by the same two nationally certified fitness professionals.

Data are presented as mean (M) ± standard deviation (SD) for the variables analyzed pre-training and post-training in the treatment groups. Statistical analyses and conclusions reported are based on Student's *t*-Tests assessing statistically significant differences between the group means. The confidence level was set at 95% for the calculation of significance as presented in the results section ($P<0.05$).

RESULTS

Analysis of data revealed non-significant improvements in percent body fat, lean weight, fat weight, systolic blood pressure, and diastolic blood pressure for both the exercise only group and the exercise plus electrical stimulation group (see Table 3).

Low Back Pain

The exercise only group attained a significant reduction in low back pain of -2.1 points on the 9-point pain scale ($t=4.68$; $P<0.001$). The exercise plus electrical stimulation group attained a significant reduction in low back pain of -2.4 on the 9-point pain scale ($t=5.53$; $P<0.001$). There were no statistically significant differences between the two training groups for changes in low back pain (see Table 3).

Low Back Fatigue

The exercise only group experienced a significant reduction in low back fatigue of -1.9 on the 9-point fatigue scale ($t=5.38$; $P<0.001$). The exercise plus electrical stimulation group experienced a significant reduction in low back fatigue of -2.3 points on the 9-point fatigue scale ($t=5.77$; $P<0.001$). There were no statistically significant differences between the two training groups for changes in low back fatigue (see Table 3).

Low Back Strength

The exercise only group achieved a non-significant increase in low back strength of +17.1 lbs ($t=1.88$; $P=0.06$). The exercise plus electrical stimulation group achieved a significant increase in low back strength of +24.3 lbs ($t=2.34$; $P=0.02$). However, there were no statistically significant differences between the two training groups for changes in low back strength.

Table 3. Nine-Week Changes for the Exercise-Only Group and the Exercise Plus Electrical Stimulation Group (n=77).

Assessment Parameter	Exercise Only (n=35)		Exercise Plus Electrical Stimulation (n=42)	
	Pre	Post	Pre	Post
	(M ± SD)		(M ± SD)	
Low Back Pain (1-9)	5.8 ± 1.54	3.7 ± 2.08*	6.0 ± 2.05	3.6 ± 1.98*
Low Back Fatigue (1-9)	5.5 ± 1.56	3.6 ± 1.49*	5.5 ± 1.94	3.2 ± 1.62*
Low Back Strength (lbs)	47.9 ± 29.3	65.0 ± 44.0	54.4 ± 37.1	78.7 ± 55.5*
Percent Body Fat (%)	26.9 ± 5.9	25.3 ± 6.3	24.9 ± 6.9	23.3 ± 6.8
Lean Weight (lbs)	129 ± 33.9	131 ± 35.0	131 ± 31.1	134 ± 32.6
Fat Weight (lbs)	46.8 ± 16.4	43.8 ± 16.5	44.9 ± 20.3	41.7 ± 19.5
Systolic BP (mmHg)	127 ± 18.5	125 ± 15.8	126 ± 14.2	123 ± 12.7
Diastolic BP (mmHg)	75.8 ± 11.2	74.6 ± 9.3	75.3 ± 9.3	74.1 ± 8.1

*Statistically significant change in pre to post means ($P<0.05$).

DISCUSSION

The findings from this study indicate that a basic and brief program of strength and endurance exercise is safe for people who experience varying levels of low back pain and low back fatigue. Of the 82 subjects who began the study, 77 finished the 9-wk training program for a 94% completion rate. All of the subjects performed more than 80% of their scheduled and supervised exercise sessions, with many attaining a 100% attendance record. None of the subjects who dropped out of the study did so due to increased low back pain or fatigue.

The study results also suggest that a basic and brief program of strength and endurance exercise is an effective means for reducing low back pain and low back fatigue. Subjects in both the exercise-only group and the exercise plus electrical stimulation group experienced significant reductions in low back pain (average of -2.3 on the 9-point pain scale) and low back fatigue (average of -2.1 on the 9-point fatigue scale).

Both groups increased low back strength, but only the exercise plus electrical stimulation condition attained a statistically significant strength grain. Although less definitive, this result was similar to our previous findings on calf muscle strength (28). In these studies, electrical

stimulation administered between resistance training sessions appeared to facilitate muscle recovery and enhance strength development. Several other studies have indicated that supplemental electrical stimulation may increase the rate of muscle remodeling and strength gain (7,9,15,19,27). Possible mechanisms by which electrical stimulation may enhance the strength-building effects of resistance exercise include nitric oxide production, cellular fluid shifts, protein clearance, and angiogenesis, as well as inducement of mRNA transcriptional proteins PGC-1 alpha and VEGF (2,5,7,18,27).

It has been suggested that the enhanced muscle recovery associated with electrical stimulation application between training sessions enables more frequent increases in the exercise resistance, thereby providing opportunity for greater strength gains in a given time period (27,28,30). It has been further proposed that there may be an inverse relationship between increased muscle strength and decreased muscle fatigue, and that electrical stimulation may facilitate improvement in both areas (28).

Although that relationship was supported by research on calf muscle fatigue (28), it was not observed in this study or in our previous study on low back muscle fatigue (29). However, it is possible that electrical stimulation may enhance the effects of resistance exercise in people who have higher levels of low back muscle fatigue and/or low back muscle pain. In the present study, 15 of the subjects experienced a 4-point or greater reduction in low back muscle fatigue on the 9-point fatigue scale. Of these, 10 were in the exercise plus electrical stimulation group and 5 were in the exercise only group. Similarly, 16 of the subjects experienced a 4-point or greater reduction in low back pain on the 9-point pain scale. Of these, 10 were in the exercise plus electrical stimulation group and 6 were in the exercise only group. Notably, 66% of the subjects who reported at least a 4-point improvement in low back muscle fatigue and 60% of the subjects who reported at least a 4-point reduction in low back pain performed the exercise program and administered electrical stimulation between training sessions. Therefore, it is recommended that further study be conducted with more symptomatic low back patients to determine whether the combination of exercise plus electrical stimulation may be a more effective intervention than exercise alone.

CONCLUSIONS

Based on the findings from this study, a basic and brief program of strength and endurance exercise significantly reduced low back pain and low back muscle fatigue in subjects who suffer from these common conditions. The results also indicate that the same exercise program in combination with supplemental electrical stimulation significantly increased low back strength in subjects who experience low back pain and fatigue. There were indications that supplemental electrical stimulation may enhance the effects of exercise for reducing low back pain and low back fatigue in individuals who are more symptomatic.

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