

UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

THE EFFECTS OF ELECTRICAL MUSCLE STIMULATION TRAINING ON THE
STRENGTH AND ENDURANCE OF THE GLUTEUS MUSCLES

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Science

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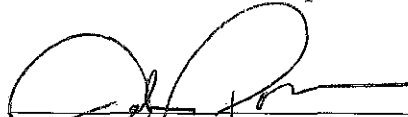
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THE EFFECTS OF ELECTRICAL MUSCLE STIMULATION TRAINING ON THE
STRENGTH AND ENDURANCE OF THE GLUTEUS MUSCLES

By Joshua M. Wilson

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Exercise Physiology

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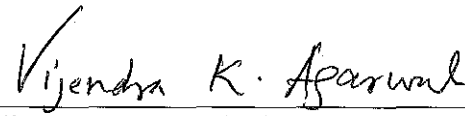
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ABSTRACT

Wilson, J.M. The effects of electrical muscle stimulation training on the strength and endurance of the gluteus muscles. MS in Clinical Exercise Physiology, December, 2010, 38pp. (J. Porcari)

This study sought out to test the effectiveness of using electrical muscle stimulation (EMS) on increasing strength and endurance of the gluteus muscles compared to volitional exercise. Seventy-two female volunteers between the ages of 20 and 60 years old were assigned to either an EMS (n=24), volitional exercise (n=24), or control group (n=24). The EMS group underwent stimulation 5 days per week for 30 minutes each day at the highest tolerable level for 6 weeks. The volitional exercise group completed 3 sets of 10 quadruped hip extensions on each leg, 5 times per week, for 6 weeks. Subjects were tested at the beginning, mid-point, and end of the study. Isometric strength of the gluteal muscles was tested using a Chatillon CSD 200 Dynamometer; endurance was measured using a hip bridge movement. The stimulation group had a 15% increase in gluteal strength compared to only a 9% increase of gluteal strength in the volitional exercise group. Gluteal endurance increased by 29% in the stimulation group compared to 26% in the volitional exercise group. The findings of this study show that there were no significant differences in gluteal strength or endurance between groups.

ACKNOWLEDGEMENTS

“Created on indistinguishable pillars of strength, intellectual astuteness, and the innate ability to protect, a man is an individual who displays the capability to articulate in speech, derive his answers from abstract reasoning, and is the living representation of the authority Christ vested into an individual to accomplish all things.”....To my father and brother, I thank you both for all of your encouragement and for showing me what it is to be a man.

To my beautiful fiancé, I thank you for your nurturing spirit and always having the words to say in encouraging me to stay the course.

To my partner in crime, Meghan Sandve, I’ve enjoyed working with you through all 72 butts!!!

I would like to thank Sarah Horlitz and Mary Patrek for all their time and effort in making sure this study went smoothly!

To Dr. John Porcari, thank you so much for all of your support! I can say with certainty that because of your help, I am that much closer to achieving the goal and dream that I have set out for myself.

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INTRODUCTION

Electrical muscle stimulation (EMS) is a therapeutic modality that has been used by physical therapists for many years as a method of rehabilitation. EMS is the application of electrical current to the neuromuscular junction and surrounding muscle fibers to elicit a muscle contraction (5, 14). The ability of EMS protocols to improve the skeletal muscle performance of healthy muscles has been accepted and demonstrated both in research studies and in rehabilitation practice (3, 6, 7). When traditional exercise is not possible due to a type of physical impairment, EMS can maintain muscular strength and lessen muscle atrophy due to immobility.

During the 1960s, Dr. Yadov Kots, a Russian scientist, used EMS to help improve the strength of elite Russian athletes (8, 10). This was the first recorded use of EMS in the fitness world. From that time in the 1960s until now, there have been numerous studies showing the usefulness of EMS training (1, 2, 4, 8, 9, 10, 11, 12, 13). A major focus of research has been on the abdominal musculature.

In 1987, Alon et al. (1) compared the effects of electrical stimulation and volitional exercise on abdominal muscle strength and endurance. Subjects were randomly assigned to a control, stimulation, volitional exercise, or exercise combined with stimulation group. The group that received stimulation in conjunction with exercise demonstrated the largest increase in abdominal strength, while the stimulation group was

the second best mode. It was concluded that combined exercise and stimulation may prove to be the most effective method of improving abdominal strength. A subsequent study conducted by Alon and Taylor (2) found that electrically-induced, minimal visible tetanic contractions could also enhance the strength of the abdominal musculature. Strength increased by 11% and 14% after 2 and 4 weeks of stimulation, respectively.

In 2005, Porcari et al. (10) tested the Slendertone Flex, an abdominal stimulation device manufactured by Bio-Medical Research, Ltd (Galway, Ireland). Stimulation was done 5 days per week for 8 weeks. Abdominal strength increased 49% and abdominal endurance increased 72% compared to a non-exercising control group. Due to the effectiveness of the Slendertone Flex, this same company developed a product to strengthen and tone the buttocks. It is called the Slendertone Bottom Toner. The purpose of this study was to test the effects of the Slendertone Bottom Toner on the strength and endurance of the gluteus muscles. This test was part of a larger study which investigated the tone, firmness, and perceived satisfaction of the gluteus muscles.

METHODS

Subjects

The subjects consisted of seventy-two female volunteers from the La Crosse, Wisconsin area and were recruited via an advertisement in the local newspaper. Inclusion criteria for this study required potential subjects to be between the ages of 20 and 60 years of age, have a Body Mass Index (BMI) between 18-32, and not have been involved in any type of formal lower body strength training program (e.g. squats) within the previous 6 months. Additionally, individuals who were pregnant, had been pregnant

within the last 3 months, had a cardiac pacemaker, had any sort of abdominal implant (e.g., IUD), had any visible skin injury or disease on their buttocks, had a history of heart disease or stroke, had epilepsy, had diabetes, or had any other medical condition involving the abdomen (e.g., hernia, abdominal ulcer) were excluded from the study.

All subjects attended an informational session and signed an informed consent form prior to beginning the study. Subjects were randomly placed into a control, exercise, or stimulation group. All three groups were told not to alter their diet or current exercise regimen (except that prescribed as part of the study) in any way over the course of the study. All subjects received \$200 and a Slendertone Bottom Toner at the conclusion of the study.

Testing

All three groups underwent an identical battery of tests at the start (baseline) of the study and after the 4th and 6th week (end of the study). The tests were administered in the same order for all subjects and the measurements at each station were made by the same research assistant for all testing sessions. Subjects initially completed a series of questionnaires and then had buttocks circumference, muscle tone, strength, and endurance assessed. Height and weight were also assessed using a standard laboratory scale.

Muscle Strength

Strength of the buttocks was assessed using an isometric hip extension movement. Measurements were made using a Chatillon CSD 200 Dynamometer (Ametek, Inc.,

Paoli, PA) that was mounted into a frame attached to a stable platform. Subjects were asked to lay face-down on the platform with their right leg bent to 90 degrees. The head of the dynamometer was placed on the back of the thigh, just above the knee. By maintaining the knee at 90 degrees of flexion, this position could be repeated for future testing sessions. Subjects were then asked to extend the hip, pushing the back of their thigh against the force transducer as forcefully as possible. Each subject completed 5 trials, with the average of the two highest values used in the analysis.

Muscle Endurance

Endurance of the buttocks was assessed using a hip bridge movement. Subjects were asked to lay supine on an exercise mat. They then bent their knees and brought their feet in towards their buttocks. They then assumed a bridge position by extending the hips and bringing their buttocks off of the mat. The correct bridge position was with the lower leg perpendicular to the floor and the back in a straight line. Subjects were asked to hold this position for as long as possible. A foam block was placed $\frac{1}{2}$ inch underneath the buttocks of the subject when they were in the "up" position. When the subjects could no longer hold the correct position (i.e., their buttocks touched the foam block) the test was terminated. If the subjects were able to hold the bridge position for more than 3 minutes, a 5 kg weight was placed on their hips. Total endurance time was measured in seconds.

Training

Subjects in the stimulation group underwent stimulation 5 times per week for 6 weeks. Each session was 30 minutes in duration. The EMS device used in the current study was the Slendertone Bottom Toner. Subjects used Program 4, which uses a cycle of an 8 second contraction followed by a 12 second rest phase. Each subject was given an individual orientation session, during which they completed their first stimulation session. All other stimulation sessions were completed on their own. Subjects were encouraged to use the highest tolerable level on their stimulator to achieve the strongest possible contractions. Subjects recorded the maximum intensity reached during each stimulation session in a training log.

Subjects in the exercise group completed 3 sets of 10 quadruped hip extensions on each leg, 5 times per week, for 6 weeks. Subjects were given individual instruction on how to perform the exercise properly and completed their first exercise session under the supervision of the principal investigator. The number of repetitions completed during each training session was recorded in a training log.

Statistical Analysis

All data are presented as means and standard deviations. One-way ANOVA was used to test for differences between groups for all pre-testing variables. Differences within each group across the study period were assessed using a 2-way ANOVA with repeated measures (Group X Time). If there was a significant F ratio, Tukey's post-hoc tests were used to isolate pairwise differences. To determine differences between groups

across the study period, changes scores (Pre-test to 4 Week and Pre-test to 6 Week) were calculated and compared using 1-way ANOVA. If there was a significant difference between groups, Tukey's post-hoc tests were used to make pairwise comparisons. Reliability of all test measurements was determined using intraclass correlations. Alpha was set at .05 to achieve statistical significance for all analyses.

RESULTS

All 72 subjects initially enrolled successfully completed the study. Descriptive characteristics of the subjects are presented in Table 1. There were no significant differences between the three groups for demographic characteristics or any of the other pre-test measures.

Table 1. Descriptive characteristics of the subjects at the beginning of the study.

Group (n)	Age (yr)	Height (cm)	Weight (kg)	BMI
Control (24)	39.5±9.85	163.8±8.30	66.3±9.25	24.7±3.14
Exercise (24)	38.1±12.81	164.6±7.63	67.1±9.40	24.8±2.93
Stimulation (24)	40.6±11.53	162.9±6.55	66.6±9.17	25.1±3.74

The stimulation group was urged to use as high intensity as possible in order to receive forceful muscular contractions. The peak intensity for each workout was recorded in a daily log. A weekly summary of the data is presented in Table 2. All subjects completed 30 stimulation sessions, as prescribed. The exercise group was instructed to complete 3 sets of 10 quadruped hip extensions on each leg, 5 times per

week (total of 60 contractions per session). All subjects in the exercise group completed 60 contractions per session for 30 sessions.

Table 2. Average stimulator intensity levels used during the study.

	Average	Range
Week 1	76 $\pm$ 12.1	55-99
Week 2	83 $\pm$ 11.3	64-99
Week 3	87 $\pm$ 11.5	64-99
Week 4	87 $\pm$ 11.7	64-99
Week 5	90 $\pm$ 11.0	64-99
Week 6	91 $\pm$ 10.5	69-99

Changes in buttocks strength and endurance are presented in Table 3. For strength, both the exercise and stimulation groups had a significant improvement from pre-test to 4 weeks and from pre-test to 6 weeks compared to the control group. The magnitude of the strength improvement was not significantly different between these two groups, however. The reliability of the strength measurements was $R=.93$. For endurance, both the exercise and stimulation groups had a significant improvement from pre-test to 6 weeks. Both groups also had an improvement from pre-test to 4 weeks; however only the change for the stimulation group was significant. Again, the magnitude of the improvement from pre-testing was similar for the exercise and stimulation groups. Reliability of the endurance measurements was $R=.83$.

Table 3. Changes in buttocks strength and endurance over the course of the study.

	Pre-test	4 Week	6 Week
Strength (kg)			
Control	25.2±6.17	25.0±6.01	25.7±7.22
Exercise	24.1±8.33	26.0±8.09*#	26.2±8.91*#
Stimulation	23.4±7.27	25.4±8.37*#	26.2±8.35*#
Endurance (sec)			
Control	234±52.0	244±59.8	258±61.8
Exercise	240±91.3	267±83.5	303±96.0*#
Stimulation	238±75.2	278±90.3*	306±94.8*#

* Significantly different than pre-test ($p < .05$)

Change from pre-test is significantly different than the change for the control group at the same time point ($p < .05$)

DISCUSSION

The major finding of this study was that use of the Slendertone Bottom Toner was just as effective as volitional exercise in improving the strength and endurance of the buttocks (bottom) musculature. After 6 weeks of training, buttocks strength improved 9% and 15% in the exercise and stimulation groups, respectively. Even though there was a tendency for the stimulation group to have a larger improvement, the magnitude of the improvement was similar between groups. The improvement in strength seen in the current study with EMS was less than that seen in previous studies in our laboratory

where stimulation was applied to the abdominal muscles. It was hypothesized that because the buttocks region is such a complex joint, with multiple muscles crossing the hip joint, it may have been more difficult to isolate and test the muscles that had been targeted with the stimulation when compared to studies involving the abdominals. Additionally, measurement of hip extension strength could have been limited by the range of motion of the hip flexors (on the front of the hip). If a subject had poor hip flexor flexibility, they would not have been able to extend their hip backwards and push against the force transducer, thus limiting the amount of improvement seen. However, this limitation would have affected both the exercise and stimulation groups.

Muscular endurance also increased significantly following exercise and EMS training. The exercise group improved by 26% and the stimulation group improved by 29%. Again, the magnitude of the improvement was less than seen in previous studies of abdominal stimulation, where increase of 72% and 170% were seen. The smaller increase again probably has to do with the difficulty in isolating the gluteal muscles for testing purposes. Ten different exercises were tried to isolate and specifically fatigue the muscles of the buttocks region, specifically the gluteus maximus. With many of the exercises, it was difficult to maintain the correct testing position once subjects got fatigued (i.e., they would shift their body weight or change their body position slightly to compensate, thus prolonging the test). The hip bridge exercise was chosen because it was the easiest to control in terms of a reproducible testing position and objective criteria for test termination. Overall, positive results in using electrical stimulation for muscular strength and endurance may be contingent upon the high quality of the stimulator and having good electrodes.

CONCLUSION

Use of the Slendertone Bottom Toner resulted in similar improvements in buttocks strength and endurance compared to volitional exercise. For those individuals who either cannot or do not want to perform volitional exercise, the Slendertone Bottom Toner is a viable alternative for training the buttocks region. However, subjects who were in the stimulation group had to wear the Slendertone Bottom Toner belt for 30 minutes a day for 5 days a week. The volitional exercise group only performed their lower body exercises for approximately 5 minutes a day for 5 days a week and achieved similar results as the stimulation group. The consumer will need to decide whether or not they will be willing to wear the belt for 30 minutes each day for 5 days a week to achieve similar results compared to the volitional exercise group.

REFERENCES

1. Alon G, McCombe SA, Koutsantinis S, Stumphauzer LJ, Burgwin KC, Parent MM, Bosworth RA. Comparison of the effects of electrical stimulation and exercise on abdominal musculature. *The Journal of Orthopedic and Sports Physical Therapy*. 1987; 8: 567-573.
2. Alon G, Taylor DJ. Electrically elicited minimal visible tetanic contraction and its effect on abdominal muscles strength and endurance. *European Journal of Physical Medicine and Rehabilitation*. 1997; 7: 2-6.
3. Avila M, Brasilerio J, Salvini T. Electrical stimulation and isokinetic training: Effects on strength and neuromuscular properties of healthy young adults. *Brazilian Journal of Physical Therapy*. 2008;12(6): 400-435.
4. Banerjee P, Caulfield B, Crowe L, Clark AL. Prolonged electrical muscle stimulation exercise improves strength, peak VO₂, and exercise capacity in patients with stable chronic heart failure. *Journal of Cardiac Failure*. 2009;15(4): 319-326.
5. Bax L, Verhagen A. Does neuromuscular electrical stimulation strengthen the quadriceps femoris? *Sports Medicine*. 2005;35(3): 191-212.
6. Eyigor S, Hepguler S, Capaci K. A comparison of muscle training methods in patients with knee osteoarthritis. *Clinical Rheumatology*. 2004;23(2): 109-115.
7. Gregory C, Bickel C. Recruitment patterns in human skeletal muscle during electrical stimulation. *Physical Therapy*. 2005;85(4): 358-364.
8. Kots Y. Electrostimulation. Symposium on Electrostimulation of Skeletal Muscles. In: Canadian Soviet Exchange Symposium; 1977 Dec 6-10: Concordia University; 1977.
9. Porcari JP, McLean KP, Foster C, Kernozek T, Crenshaw B, Swenson C. Effects of electrical muscle stimulation on body composition, muscle strength, and physical appearance. *Journal of Strength and Conditioning Research*. 2002;16(2): 165-172.

10. Porcari JP, Miller J, Cornwell K, Foster C, Gibson M, McLean K, Kernozek T. The effects of neuromuscular electrical stimulation training on abdominal strength, endurance, and selected anthropometric. *Journal of Sports Science and Medicine*. 2005;4: 66-75.
11. Porcari JP, Turnwall C, Olsen J, Meyer D, Stanek K, Foster C. The effects of 6 weeks of high intensity neuromuscular electrical stimulation on abdominal strength and endurance, core strength, abdominal girth, and perceived body shape and satisfaction. 2008 (In Review)
12. Selkowitz DM. Improvement in isometric strength of the quadriceps femoris after training with electrical stimulation. *Physical Therapy*. 1985;65(2). 186-196.
13. Talbot LA, Gaines JM, Ling SM, Metter EJ. A home-based protocol on electrical muscle stimulation for quadriceps muscle strength in older adults with osteoarthritis of the knee. *The Journal of Rheumatology*. 2003;30(7): 1571-1578.
14. Windley TC. The efficacy of neuromuscular electrical stimulation for muscle-strength augmentation. *Human Kinetics*. 2007;12(1): 39-42.

APPENDIX A
BOTTOM TONER CONSENT FORM

INFORMED CONSENT

Slendertone Bottom Toner Stimulation Study

I, _____ (print name) give my informed consent to participate in a research project designed to investigate the potential benefits of using the Slendertone Bottom Toner training device.

Explanation of the Study

I have been informed that this study is open to individuals between the ages of 20-60 years of age who have not engaged in a regular lower body resistance training program in the past 6 months, do not have a history of heart disease or stroke, do not have a cardiac pacemaker, do not have an abdominal implant of any type (e.g., IUD), do not have any visible skin injury or disease on their buttocks, do not have any medical condition involving the abdomen (e.g., hernia), are not pregnant, or who have been pregnant in the past 3 months, are not epileptic, and are not diabetic. As a subject in this study, I realize that I may be placed in one of three groups: either a control group, an exercise group, or a stimulation group. Regardless of which group I am placed in, I have been informed that I must maintain my current exercise and lifestyle habits (e.g., diet) over the course of the study. I have been informed that if I am placed in the control group, I will only undergo the testing portion of the study. If I am placed in the exercise group, I will be required to perform 3 sets of 10 hip extensions exercises with each leg while I am on my hands and knees, 5 days per week for 6 weeks. I have been informed that if I am placed in the stimulation group, I must participate in 30 minute stimulation sessions 5 days per week for 6 weeks. These sessions will involve a commercially available belt that provides an electrical current to the muscles of my buttocks, resulting in muscular contractions. The first of these sessions must be completed at the University of Wisconsin-La Crosse under the supervision of a trained research assistant. All other stimulation sessions will be conducted on my own. I have also been informed that I must report to the testing laboratory three times during the 6-week study: at the beginning, 4-week point, and 6-week point (end) of the study.

Testing

I have been informed that the testing will involve measurement of height and body weight, hip circumference, buttocks strength and endurance, and evaluation of how I perceive the appearance, firmness, and tone of my bottom. Height and body weight will be measured with a standard laboratory scale. Circumference measurements of my hips will be made with a tape measure. For the buttocks strength measurement I will be lying face down on a padded table. I will be asked to exert as much force as possible while trying to lift my dominant leg off of the table. To determine the endurance of my buttocks muscles, I will be asked to perform as many hip extensions as possible while on my hands and knees. To determine muscle tone, I will lay face-down on an examination table. A hand-held device designed to measure muscle tone (a myotonometer) will be pressed onto my buttocks, while force measurements are taken. These measurements will

be taken while my buttocks are relaxed, and when they are maximally contracted. Because of the potentially embarrassing nature of this measurement, this test will be conducted by a female research assistant and all subjects will wear identical nylon shorts that will be provided. I will also be asked to evaluate the appearance and tone of my bottom by filling out a series of questionnaires.

Risks and Discomforts

I have been informed that I can stop the testing or training at any time I wish. If I am in the stimulation group, the type of electrical stimulation used in this study will result in strong muscular contractions of the buttocks. Additionally, I may experience a prickling sensation under the electrodes during stimulation and skin redness at the electrode sites following periods of stimulation. To minimize any risks, an explanation and demonstration regarding the proper use of the stimulator will be given to me. Additionally, the first stimulations session will be under the supervision of the study staff. I have been informed that like any unaccustomed muscular activity (exercise), this may result in muscle soreness. If I am in the exercise group, I have been informed that performing hip extension exercises may also result in muscle soreness.

Benefits to be Expected

I have been informed that participation in this study may include increases in strength, tone, and firmness of the buttocks musculature and an enhanced feeling about the appearance of my bottom. For the general public, information relative to the effectiveness of buttocks stimulation will be obtained. I have also been informed that if I successfully complete the study I will receive \$200, plus a Slendertone Bottom Toner (retail value of \$150). If I drop out of the study for any reason, the \$200 will be prorated based upon my time of involvement and distributed accordingly.

Confidentiality of Data Collected

I consent to the publication of the results of this study so long as the information is disguised so that no identification of individual subjects can be made and only summary data is used. I further have been informed that although a record will be kept of my participation in the experiment, all subjects will be identified by number only.

Responsibilities of the Participant

I have been informed that if any symptoms or complications occur before, during, or after the research project, I will inform the staff. I consider myself to be in good health and to my knowledge I do not have any limiting physical condition or disability, especially related to my heart, which would preclude my participation in the tests described above. If I become pregnant during the course of the study, I will immediately inform the staff and withdraw from the study. I have also been informed that regardless of which group I am in, I am to maintain my current exercise and lifestyle habits over the course of the

study. If my body weight goes up or down by more than 5 pounds from the beginning to the end of the 6-week study period, I will be removed from the study at that time.

I have been informed that in the unlikely event of any injury or illness occurring as a result of this research, the Board of Regents of the University of Wisconsin System, and the University of Wisconsin-La Crosse, their officers, agents and employees, do not automatically provide reimbursement for medical care or other compensation. You or your third party payor, such as your health insurer or Medicare, must provide payment for treatment of any injury or illness. If any injury or illness occurs in the course of the research, or for more information, please notify the investigator in charge. I have been informed that I am not waiving any rights that I may have for injury resulting from negligence of any person or the institution.

Contact Person

If I have any other questions that arise I may feel free to contact the principal investigator John Porcari at (608) 785-8684. Questions in regards to the protection of human subjects may be addressed to the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects at (608) 785-8124.

Participant's Signature: _____ Date: _____

Investigator's Signature: _____ Date: _____

APPENDIX B

SLENDERTONE STIMULATION TRAINING LOG

Slendertone® Bottom Toner Training ScheduleParticipant Study Number: BMR-09-2012 - **Instructions for Participant:**

Please fill in the date, as well as the peak intensity of muscle stimulation for each of your 30-minute muscle stimulation sessions.

Please bring this schedule and your muscle stimulation belt to the study clinic for each of your scheduled visits.

Week 1

Date	Session	Program #	# of Minutes	Peak Intensity Reached
	1	4	30 minutes	
	2	4	30 minutes	
	3	4	30 minutes	
	4	4	30 minutes	
	5	4	30 minutes	

Week 2

Date	Session	Program #	# of Minutes	Peak Intensity Reached
	1	4	30 minutes	
	2	4	30 minutes	
	3	4	30 minutes	
	4	4	30 minutes	
	5	4	30 minutes	

Week 3

Date	Session	Program #	# of Minutes	Peak Intensity Reached
	1	4	30 minutes	
	2	4	30 minutes	
	3	4	30 minutes	
	4	4	30 minutes	
	5	4	30 minutes	

Participant Initials

Date

Slendertone® Bottom Toner Training ScheduleParticipant Study Number: BMR-09-2012 - **Week 4**

Date	Session	Program #	# of Minutes	Peak Intensity Reached
	1	4	30 minutes	
	2	4	30 minutes	
	3	4	30 minutes	
	4	4	30 minutes	
	5	4	30 minutes	

Week 5

Date	Session	Program #	# of Minutes	Peak Intensity Reached
	1	4	30 minutes	
	2	4	30 minutes	
	3	4	30 minutes	
	4	4	30 minutes	
	5	4	30 minutes	

Week 6

Date	Session	Program #	# of Minutes	Peak Intensity Reached
	1	4	30 minutes	
	2	4	30 minutes	
	3	4	30 minutes	
	4	4	30 minutes	
	5	4	30 minutes	

Participant Initials

Date

APPENDIX C

SLENDERTONE EXERCISE TRAINING LOG

Quadruped Hip Extension Training ScheduleParticipant Study Number: BMR-09-2012 -

Please complete 3 sets of 10 quadruped hip extensions on each of your Right and Left Legs.

Please DO NOT EXCEED 30 hip extensions for each leg and do not do all 30 repetitions at one time; alternate the right and left leg – 10 repetitions at a time.

Week 1

Date	Session	Quadruped Hip Extensions Each side	Number of hip extensions completed on Left Side	Number of hip extensions completed on Right Side
	1	30		
	2	30		
	3	30		
	4	30		
	5	30		

Week 2

Date	Session	Quadruped Hip Extensions Each side	Number of hip extensions completed on Left Side	Number of hip extensions completed on Right Side
	1	30		
	2	30		
	3	30		
	4	30		
	5	30		

Week 3

Date	Session	Quadruped Hip Extensions Each side	Number of hip extensions completed on Left Side	Number of hip extensions completed on Right Side
	1	30		
	2	30		
	3	30		
	4	30		
	5	30		

Participant Initials**Date**

Participant Study Number: BMR-09-2012 -

Please DO NOT EXCEED 30 hip extensions of each leg.

Week 4

Date	Session	Quadruped Hip Extensions Each side	Number of hip extensions completed on Left Side	Number of hip extensions completed on Right Side
	1	30		
	2	30		
	3	30		
	4	30		
	5	30		

Week 5

Date	Session	Quadruped Hip Extensions Each side	Number of hip extensions completed on Left Side	Number of hip extensions completed on Right Side
	1	30		
	2	30		
	3	30		
	4	30		
	5	30		

Week 6

Date	Session	Quadruped Hip Extensions Each side	Number of hip extensions completed on Left Side	Number of hip extensions completed on Right Side
	1	30		
	2	30		
	3	30		
	4	30		
	5	30		

Participant Initials

Date

APPENDIX D
REVIEW OF LITERATURE

REVIEW OF LITERATURE

INTRODUCTION

Electrical muscle stimulation (EMS) is a therapeutic modality that has been used by physical therapists for many years as a method of rehabilitation. EMS is the application of electrical current to the neuromuscular junction and surrounding muscle fibers to elicit a muscle contraction (5, 14). The ability of EMS protocols to improve the skeletal muscle performance of healthy muscles has been accepted and demonstrated both in research studies and in rehabilitation practice (3, 6, 7). When traditional exercise is not possible due to any type of physical impairment, EMS may be useful for maintaining muscular strength and lessening the effects of immobility. From its conception in a therapeutic state to now its role in fitness, the purpose of this paper is to review the literature concerning the use of EMS as a training adjunct for the purpose of developing muscular strength and endurance.

EFFECTS OF MUSCLE STIMULATION ON STRENGTH AND ENDURANCE

During the 1960s, Dr. Yadov Kots, a Russian scientist, used EMS to help improve the strength of elite Russian athletes. The study found strength improvements of 30- 40% using EMS (8, 10). Prior to that time, EMS was primarily viewed as an adjunctive therapy to aid in "muscle re-education" and was predominantly used with people who had neurological disorders. EMS was also used often in an attempt to prevent the atrophy

that occurs when skeletal muscle is denervated. In recent years, fitness equipment companies have marketed EMS devices to healthy individuals as a way to improve muscle strength, endurance, and body composition. EMS can be utilized for various muscle groups, but is most commonly used for the abdominal region.

A study by Alon et al. (1) compared the effects of electrical stimulation and volitional exercise on the abdominal muscle strength and endurance. Subjects were randomly assigned to a control, stimulation, volitional exercise, or exercise combined with stimulation group. Maximal voluntary isometric contraction and endurance data were determined before training started. The number of repetitions and time of sustained contraction were increased by a predetermined amount during the 4 weeks of training. The group that received stimulation with exercise demonstrated the largest significant increases in abdominal strength, while the stimulation group was the second best mode. No significant change in endurance was found between the groups. It was concluded that combined exercise and stimulation may prove to be the most effective method of improving abdominal strength.

A subsequent study conducted by Alon and Taylor (2) tested to see if electrically-induced, minimal visible tetanic contractions could enhance the strength and endurance of the abdominal musculature. Sixteen males and 22 females were randomly assigned to a control or experimental group. The experimental group's stimulation protocol required them to stimulate for 3 hours a day, 5 days each week, for 4 weeks. Tests revealed a significant increase in strength of the experimental group compared to the control group. There was a mean increase of 11% and 14% after 2 and 4 weeks of stimulation

respectively. Both groups had a decrement of abdominal force that averaged 47%. The difference in force decline between groups was not significant. Subjects rated the stimulation between "comfortable to somewhat pleasant". The study found that prolonged stimulation at minimal intensity can enhance abdominal strength and is well-tolerated.

Banerjee et al. (4) evaluated training responses to prolonged EMS in patients with stable chronic heart failure. In a crossover-designed study, 10 patients were randomized to 8 weeks of training or habitual activity, before crossing over to the other limb after a washout period of 2 weeks. After training, quadriceps strength increased from 378N to 405N. This study showed that EMS can be used in sedentary adults with stable chronic heart failure to improve physical fitness. Thus, it may provide a viable alternative for patients unable to undertake more conventional forms of exercise.

A study by Talbot et al. (13) was completed to determine whether home-based EMS applied to the quadriceps femoris muscle could increase strength in older adults with knee osteoarthritis. Thirty-four adults with confirmed symptomatic knee osteoarthritis were randomized to EMS plus education or just education only. The EMS group used a portable electrical muscle stimulator 3 days a week for 12 weeks. The EMS group showed a 9.1% increase in quadriceps femoris strength compared to a 7% loss of strength in the education group. These results show that in older adults with knee osteoarthritis, a home-based EMS protocol appears to be a promising therapy for increasing quadriceps femoris strength.

Porcari et al. (11) studied the effects of self-administered EMS on changes in abdominal muscle strength and endurance, and core strength. Fifty-three adults were randomly assigned into high intensity stimulation group and a low-intensity group. Subjects were tested at baseline, 2, 4, and 6 weeks. The high intensity group had a significantly greater increase in strength at 4 weeks (19%) and 6 weeks (29%) compared to the low-intensity group. Both groups had a significant increase in core strength over the course of the study, with no differences between the groups. Results from this study indicated that high intensity EMS can significantly increase abdominal strength and endurance compared to low intensity stimulation.

Porcari et al. (9) studied the effects of self-administered EMS on changes in strength, endurance. Twenty-four adults (experimental group) stimulated their abdominals 5 days per week (20-40 minutes per session) for 8 weeks and refrained from engaging in any additional exercise during the study. A control group (n=16) refrained from exercising the abdominals or engaging in any other exercise training during the study. The stimulation group had a 49% increase in abdominal strength, whereas the control group did not change. The stimulation group also had a 72% increase in abdominal endurance when compared to the control group.

Selkowitz (12) conducted a study that investigated if the use of EMS would significantly increase isometric strength of the quadriceps femoris muscle. There was a stimulation and exercise group with 12 subjects in each. The stimulation group trained 3 days a week for 4 weeks. Both groups underwent pre and post-testing to obtain their maximum voluntary isometric contraction (MVIC). Strength results showed that although both groups demonstrated increases in isometric strength of their quadriceps

femoris muscles, training isometrically with electrical stimulation produced a significantly greater increase than volitional exercise. The relative strength improvement in the stimulation group was positively and significantly correlated with training-contraction intensity and duration. Selkowitz noted the relative increase in isometric strength, using only electrical stimulation, may be determined by the ability of the subjects to tolerate longer and more forceful contractions.

Despite the reported positive outcomes of using EMS, there is evidence that EMS is not as effective as once thought (3, 10). Porcari et al. (10) sought to test advertisement claims that EMS increased muscle strength in healthy individuals. Twenty-seven college-aged volunteers were assigned to either an EMS or control group. The EMS group underwent stimulation 3 times per week following the manufacturer's recommendations, whereas the control group underwent concurrent sham stimulation sessions. Identical pre and post-tests measured isokinetic strength. EMS had no significant effect on strength. The claims relative to the effectiveness of EMS for the apparently healthy individual were not supported by the findings of this study due to a poor stimulator and electrodes.

Avila et al. (3) assessed the effects of EMS associated with an isokinetic training program in healthy young men and women. Twenty participants (ten men, ten women) underwent an isokinetic training program for the knee extensors of both legs twice a week for 4 weeks. One limb underwent only the isokinetic strength training (exercise) while the other underwent the same training, but with EMS associated with each contraction (exercise and EMS). These results showed that by combining EMS with concurrent isokinetic training was no more effective than isokinetic training alone.

SUMMARY

Research supporting the use of EMS training for improving muscular strength and endurance have shown mixed results. A key component in determining the effectiveness of EMS training is the quality of the stimulator as well as having good electrodes. If the device can elicit strong muscular contractions, EMS training will result in positive results.

REFERENCES

1. Alon G, McCombe SA, Koutsantinis S, Stumphauzer LJ, Burgwin KC, Parent MM, Bosworth RA. Comparison of the effects of electrical stimulation and exercise on abdominal musculature. *The Journal of Orthopedic and Sports Physical Therapy*. 1987;8: 567-573.
2. Alon G, Taylor DJ. Electrically elicited minimal visible tetanic contraction and its effect on abdominal muscles strength and endurance. *European Journal of Physical Medicine and Rehabilitation*. 1997;7: 2-6.
3. Avila M, Brasilerio J, Salvini T. Electrical stimulation and isokinetic training: Effects on strength and neuromuscular properties of healthy young adults. *Brazilian Journal of Physical Therapy*. 2008;12(6): 400-435.
4. Banerjee P, Caulfield B, Crowe L, Clark AL. Prolonged electrical muscle stimulation exercise improves strength, peak VO₂, and exercise capacity in patients with stable chronic heart failure. *Journal of Cardiac Failure*. 2009;15(4): 319-326.
5. Bax L, Verhagen A. Does neuromuscular electrical stimulation strengthen the quadriceps femoris? *Sports Medicine*. 2005;35(3): 191-212.
6. Eyigor S, Hepguler S, Capaci K. A comparison of muscle training methods in patients with knee osteoarthritis. *Clinical Rheumatology*. 2004;23(2): 109-115.
7. Gregory C, Bickel C. Recruitment patterns in human skeletal muscle during electrical stimulation. *Physical Therapy*. 2005;85(4): 358-364.
8. Kots Y. Electrostimulation. Symposium on Electrostimulation of Skeletal Muscles. In: Canadian Soviet Exchange Symposium; 1977 Dec 6-10: Concordia University; 1977.
9. Porcari JP, McLean KP, Foster C, Kernozek T, Crenshaw B, Swenson C. Effects of electrical muscle stimulation on body composition, muscle strength, and physical appearance. *Journal of Strength and Conditioning Research*. 2002;16(2): 165-172.

10. Porcari JP, Miller J, Cornwell K, Foster C, Gibson M, McLean K, Kernozek T. The effects of neuromuscular electrical stimulation training on abdominal strength, endurance, and selected anthropometric. *Journal of Sports Science and Medicine*. 2005;4: 66-75.
11. Porcari JP, Turnwall C, Olsen J, Meyer D, Stanek K, Foster C. The effects of 6 weeks of high intensity neuromuscular electrical stimulation on abdominal strength and endurance, core strength, abdominal girth, and perceived body shape and satisfaction. 2008 (In Review)
12. Selkowitz DM. Improvement in isometric strength of the quadriceps femoris after training with electrical stimulation. *Physical Therapy*. 1985;65(2): 186-196.
13. Talbot LA, Gaines JM, Ling SM, Metter EJ. A home-based protocol on electrical muscle stimulation for quadricep muscle strength in older adults with osteoarthritis of the knee. *The Journal of Rheumatology*. 2003;30(7): 1571-1578.
14. Windley TC. The efficacy of neuromuscular electrical stimulation for muscle-strength augmentation. *Human Kinetics*. 2007;12(1): 39-42.