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의학석사 학위논문

Electrical stimulation on lumbar paraspinal muscle during prolonged sitting

앉은 자세에서 요부 척추 주위근의 전기자극

2015 년 2 월

서울대학교 대학원

임상의과학 전공

최 영 아

A thesis of the Master's degree

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February 2015

Seoul National University College of Medicine

Clinical Medical Sciences

Young-Ah Choi

앉은 자세에서 요부 척추 주위근의 전기자극

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이 논문을 의학석사 학위논문으로 제출함

2014년 10월

서울대학교 대학원

임상의과학 전공

최영아

최영아의 의학석사 학위논문을 인준함

2014년 12월

위 원 장 ____________________ (인)

부위원장 ____________________ (인)

위 원 ____________________ (인)

Electrical stimulation on lumbar paraspinal muscle during prolonged sitting

by

Young−Ah Choi

A thesis submitted to the Department of Clinical Medical Sciences in partial fulfillment of the requirements for the Master of Science in Clinical Medical Sciences at Seoul National University College of Medicine

February 2015

Approved by Thesis Committee:

Professor ____________________Chairman

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Abstract

Introduction: Trunk muscle weakness is a risk factor for low back pain. Prolonged sitting, mainly due to the sedentary lifestyle of modern society, can cause trunk muscle weakness. Superimposed electrical stimulation (ES) over the back extensor during strengthening exercise has been proven to increase muscle strength. The objective of this study was to assess the strengthening effect of ES on the paraspinal muscle during prolonged sitting.

Methods: Thirty healthy subjects without low back pain were randomly assigned to an ES group (n = 15) or a control group (n = 15). ES was administered over the low lumbar paraspinal muscle in a seated posture at a maximal tolerable intensity for 60 min/day, three times a week, for 4 weeks. The same protocol was used in the control group, but at minimal intensity just over the sensory threshold. Isokinetic strength of the lumbar paraspinal muscles was evaluated at baseline, 4 weeks after ES, and 8 weeks after initiation of ES with an isokinetic dynamometer (Biodex Medical dynamometer system-4) at 60°/s and 120°/s angular velocities.

Results: After 4 weeks of ES in a sitting position, the isokinetic extensor trunk muscle strength measured at 120°/s angular velocity significantly increased in the ES group ($P < 0.05$) compared with that in the control group. This effect was not maintained when measured at 4 weeks after the cessation of ES.

Conclusions: ES in a sitting position is an effective and accessible rehabilitation treatment to improve the extensor trunk muscle strength of the lumbar paraspinal muscle, although the effect is short-term.

Key words: back pain, electrical stimulation, isokinetic strength

Student Number: 2013-22611

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I. Introduction

Low back pain (LBP) is a common disorder with one of the most significant medical-cost burdens on society.(1) Increasing computer use and sitting position have become common in working environments, and a prolonged sitting position is often associated with back pain.(2) Furthermore, several subjective experiments have shown that low back discomfort increases with a prolonged seated posture, even in individuals with no history of LBP.(3-6)

Many studies have shown weakened trunk muscle strength in LBP patients compared with that in healthy subjects.(7) This is not only caused by a lack of maximal activation, as deteriorating of the extensor muscle volume(8), but also a loss of type II fibers have been demonstrated.(9) Furthermore, several studies have shown that LBP patients show reduced trunk extensor muscle endurance.(10) For individuals with LBP who had received conservative management, trunk strengthening compared with no exercise showed moderate effects on chronic pain and advantages in long-term functioning. Therefore, trunk strengthening is effective for reducing pain and improving function in LBP patients.(11)

Electrical stimulation (ES) as well as exercise can be used to selectively train specific muscles such as the erector spinae in patients with LBP.(12) Furthermore, superimposed ES over the back extensor during strengthening exercise can increase muscle strength.

However, to our knowledge, no study has performed ES over the back muscles during prolonged sitting. Previous research suggests that prolonged sitting could be a risk factor for LBP. Posterior lumbar structure weakness is a disadvantage of prolonged sitting.(6) Furthermore, ES during prolonged sitting might be easier and more convenient for modern humans than ES in the prone position. Therefore, the aim of this study was to assess for the first time the strengthening effect of ES over the paraspinal muscle during prolonged sitting. We hypothesized that ES over the lumbar paraspinal muscle during sitting would enhance back muscle strength and endurance.

II. Materials and methods

Subjects

Participants were recruited through advertisements on library bulletin boards, and this experiment was conducted at Seoul National University College of Medicine, Korea. Inclusion criteria for volunteer participation were (1) informed consent, (2) age of 20 to 39 years, and (3) good health, with no history of LBP within the last month (from onset of symptoms). Exclusion criteria were (1) history of surgery, (2) underlying cardiopulmonary disease, (3) obesity (body mass index [BMI] [kg/m^2] ≥ 25), and (4) peripheral vascular disease (e.g., venous thromboembolism). All subjects received an informational brochure and provided voluntary written informed consent before participation in this study. Subjects were allowed to withdraw from the study at any time. Sociodemographic data including sex, age, BMI (kg/m^2), smoking status (yes or no), social drinking status, and the duration of exercise per week (hours per week) were recorded, since these factors can influence back pain.(13, 14) This research protocol was reviewed and approved by the Seoul National University Hospital Institutional Review Board (IRB No: 1306-054-495).

Randomization

A prospective, randomized block design study with a single blinded evaluator was conducted. Randomization was accomplished as each participant was enrolled by sequentially assigning the subject to one of two groups based on a prearranged table of random numbers. In this way, patients were randomly allocated to either the ES group or a control (sham) group. Finally, 30 healthy subjects without LBP were randomly assigned to ES group (n=15) and control group (n=15).

Procedure

The ES group received ES over the low lumbar paraspinal muscle in a seated posture at maximal tolerable intensity for a total of 12 sessions. The control group received the same protocol but at minimal intensity just over the sensory threshold. All 30 subjects were instructed in the operation and self-application of an electrical muscle stimulator (Microstim, Medel

GmbH, Germany). The initial position of participants for ES was a normal seated posture, and participants were allowed to otherwise move freely while sitting.

ES parameters

The parameters of ES were based on the assumption that back muscle strength can be enhanced in a manner similar to that in previous studies of ES.(15, 16) For example, McQuain et al. administered low-frequency ES over the lumbar paraspinal muscle of healthy premenopausal women and found an improvement in isometric back extensor strength (8.1% increase) within the first 3 months.(17) Four square-shaped electrodes (5 × 4 cm) were simultaneously placed at the L2–L4 levels over the erector spinae muscle bulk (Figure 1). Stimulation was performed with a symmetric biphasic square shape of impulse form. An impulse width of 300 μs and frequency of 50 Hz were used. The subjects in the ES group were instructed to set the intensity of stimulation at the maximal tolerable range. However, the intensity used by subjects in the control group was just over the sensory threshold. For the duty cycle, an on time of 10 s and an off time of 40 s were applied. Subjects were allowed a 5-min warm-up and cool-down period. Three sessions of ES were administered to each participant. The duration of ES in each session was 20 min, and a 5-min rest period was provided between sessions. Therefore, the total actual stimulation period was 60 min/day. The subjects conducted this ES protocol three times a day, 3 days a week, for 4 weeks (total 12 sessions)

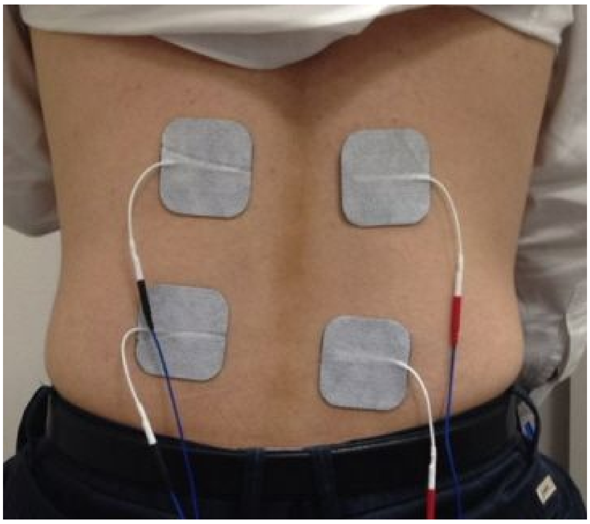

Figure 1. Four electrodes (5cm x 4cm) on the erector spinae muscles of L2–L4 levels.

Isokinetic trunk strength measurement

Measurement of isokinetic trunk extensor and flexor strength was performed with an isokinetic dynamometer (Biodex Medical dynamometer system-4) (Figure 2). The Biodex dual-position back extension/flexion attachment was connected to the dynamometer. The subjects were seated on the adjustable seat of the attached unit in the seated-compressed position with Velcro straps fastened over the torso, waist, and thighs to isolate back movement. The fixed axis of the machine was adjusted to align with the subject’s anterior superior ileac spine. Spinal range of motion was set individually, and the angular velocity was set at 60°/s and 120°/s in sequence. To minimize the effects of fatigue, a 60-s resting interval was allowed between the two velocity tests.

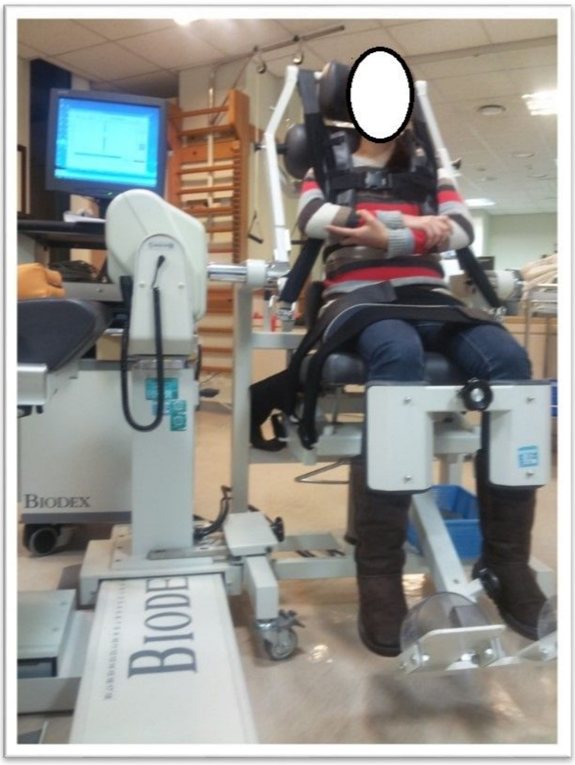

Figure 2. Isokinetic dynamometer (Biodex Medical dynamometer system-4) for isokinetic trunk extensor and flexor strength measurement.

Modified Sorensen endurance test

The participants were asked to lie down on the examination table in the prone position with the upper edge of the iliac crests aligned with the edge of the table. The lower body was fixed to the table by straps. The participants were asked to fold their arms across their chest and keep their upper body in a horizontal position. The time during which the participants kept their upper body horizontal was recorded. The participants were asked to maintain this horizontal position until they could no longer control the posture or tolerate the procedure.

Statistical analysis

Primary outcome

The primary outcome of this study was the isokinetic strength measured at 60°/s and 120°/s. Back flexor and extensor isokinetic strength were measured with an isokinetic dynamometer at baseline, 4 weeks after ES, and 8 weeks after the study. All data are presented as mean and standard deviation (SD). A repeated-measures analysis of variance (RMANOVA) with time (pre and post) and intervention (ES and control) as repeated factors was used to detect significant differences between and within groups at any time point tested. Comparisons were performed between baseline and subsequent time points (within-group differences) as well as between ES and control groups at each time point (between-group differences). Bonferroni post-hoc analysis was performed to identify any significant differences indicated. The statistical significance level was set at 5%.

Secondary outcome

The modified Sorensen endurance measurement of isometric back extension endurance was performed at baseline, 4 weeks after ES, and 8 weeks after the study. Repeated-measures analysis and Bonferroni post-hoc analysis were then performed. The overall pain and fatigue during ES was assessed by a numeric rating score (0 to 10, with higher scores representing more pain) at every ES session. Pearson chi-square test was applied for categorical data, and the Mann–Whitney *U* test and Wilcoxon rank-sum test were also used for nonparametric analysis. The statistical significance level was set at 5%.

III. Results

Comparison of epidemiologic and clinical characteristics between groups

A total of 30 subjects completed the study. There were no significant differences in sex, age, BMI (kg/m^2), smoking status (yes or no), social drinking status, or the total duration of exercise (hour per week) between groups. Characteristics of the both study populations are given in Table 1. The ES protocol was tolerated by all subjects, and subjects did not report any adverse events during the course of the study.

Primary outcome

An RMANOVA for extension and flexion peak torque at 60°/s showed no significant interaction between time and intervention or between interventions, suggesting that there was no difference between the ES group and the control group (Figures 3A and 3B). However, an RMANOVA for extension peak torque at 120°/s showed a significant interaction between time and intervention ($P = 0.011$) and time ($P = 0.031$). Post-hoc tests revealed that isokinetic extensor trunk muscle strength in the ES group at 120°/s significantly increased ($P = 0.014$) compared with that in the control group after 4 weeks of ES during sitting. Although these improvements were not present 8 weeks after the study, isokinetic extensor trunk muscle strength improved between baseline and 4 weeks after study ($P = 0.046$) (Figure 4A). Lastly, flexion peak torque at 120°/s also showed no significant interaction between time and intervention or between interventions (Figure 4B).

Table 1. Sociodemographic characteristics of the study population

Group	ES group	Control	P-value
Gender (Male : Female)	10 : 5	9 : 6	0.71
Age (mean±SD)	26.80±2.88	27.40±3.29	0.72
BMI (mean±SD)	22.35±2.75	21.41±2.75	0.55
Smoker (number)	0	1	1.00
The presence of Social drinking (number)	12	11	1.00
Exercise (hour/week)	4.40±2.68	3.58±1.78	0.52

SD: standard deviation

BMI: body mass index (kg/m^2)

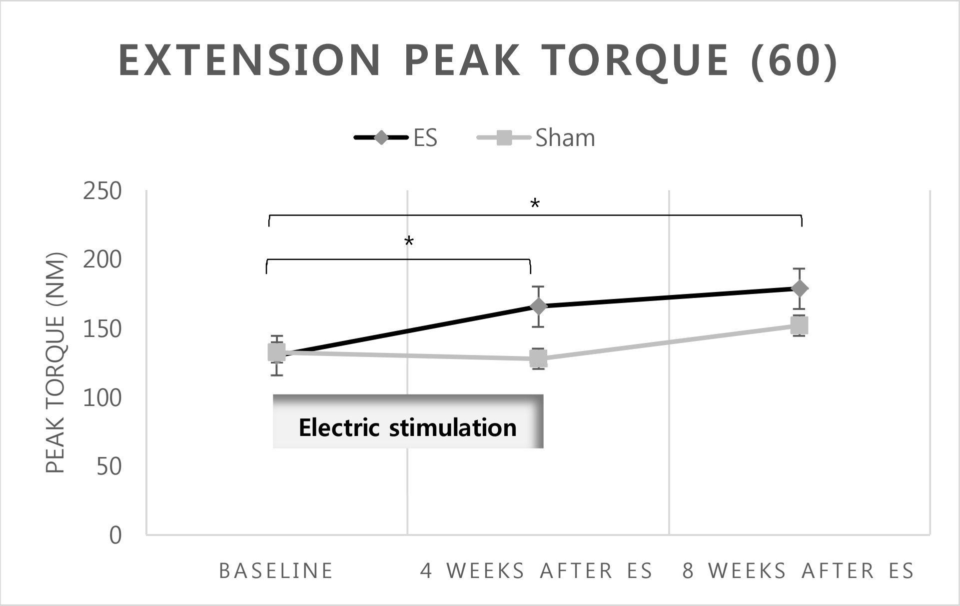

Figure 3-A. A RMANOVA for extension peak torque (60 °/s) shows no significant interaction between time and intervention or intervention.

**: between-group differences *: within-group differences
ES: electrical stimulation; RMANOVA: repeated-measures analysis of variance

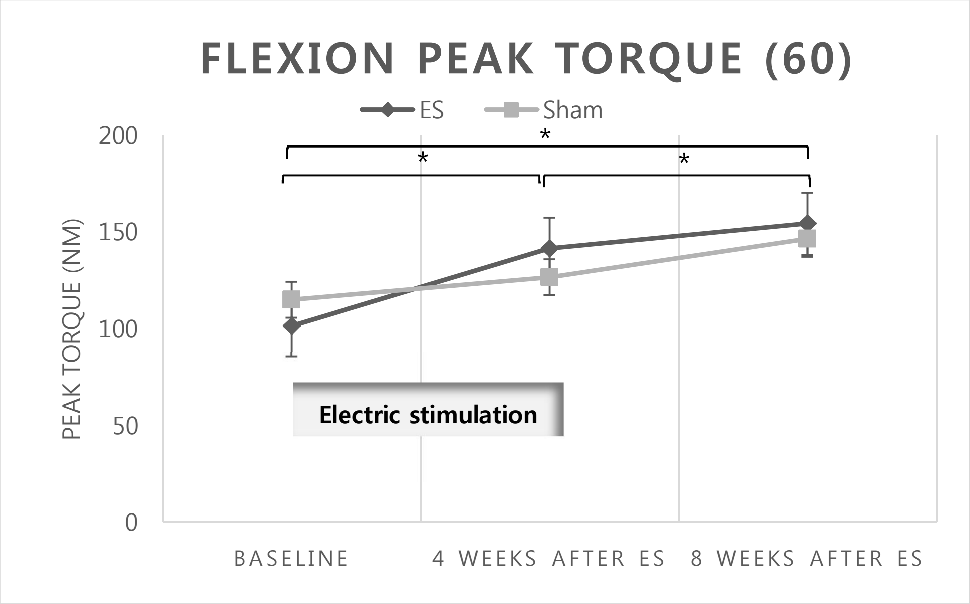

Figure 3-B. A RMANOVA for flexion peak torque (60 °/s) shows no significant interaction between time and intervention or intervention.

**: between-group differences *: within-group differences
ES: electrical stimulation; RMANOVA: repeated-measures analysis of variance

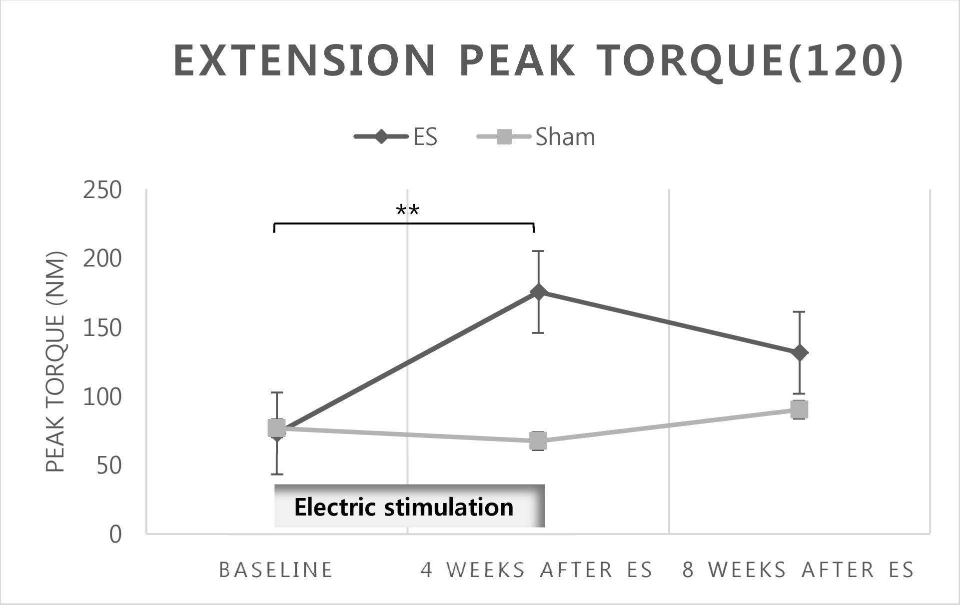

Figure 4-A. A RMANOVA for extension peak torque at 120 °/s shows significant interaction between time and intervention (P=0.011) and time (P=0.031). At post-hoc tests, isokinetic extensor trunk muscle strength of ES group at 120-degree/second velocities is significantly increased (P=0.014) compared to control group after 4 weeks of electrical stimulation program.

**: between-group differences *: within-group differences
ES: electrical stimulation; RMANOVA: repeated-measures analysis of variance

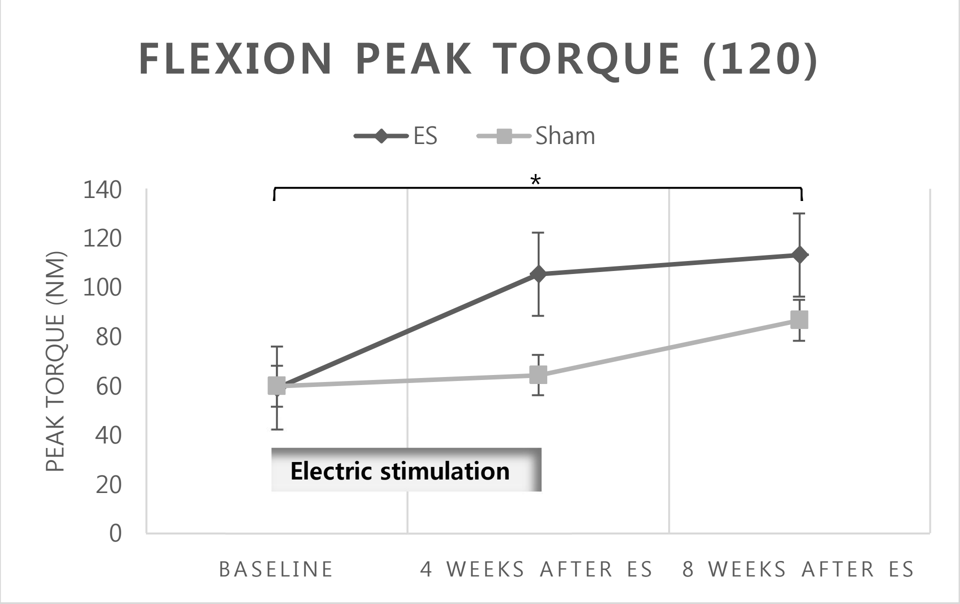

Figure 4-B. A RMANOVA for flexion peak torque (120 °/s) shows no significant interaction between time and intervention or intervention.

**: between-group differences *: within-group differences
ES: electrical stimulation; RMANOVA: repeated-measures analysis of variance

Secondary outcome

Sorenson endurance test measurements were not different between groups, but both groups showed an improvement between baseline and 4 weeks after the study ($P = 0.020$) and between 4 weeks and 8 weeks after the study ($P = 0.007$) (Figure 5). The average stimulation intensity was 18.03 ± 4.44 mA in the ES group and 2.77 ± 0.92 mA in the control group. Although subjects in the ES group reported significantly higher pain scores ($P < 0.001$) and subjective fatigue ($P < 0.001$) during and after ES, pain and fatigue were tolerable, and all subjects in the ES group completed all sessions (Table 2).

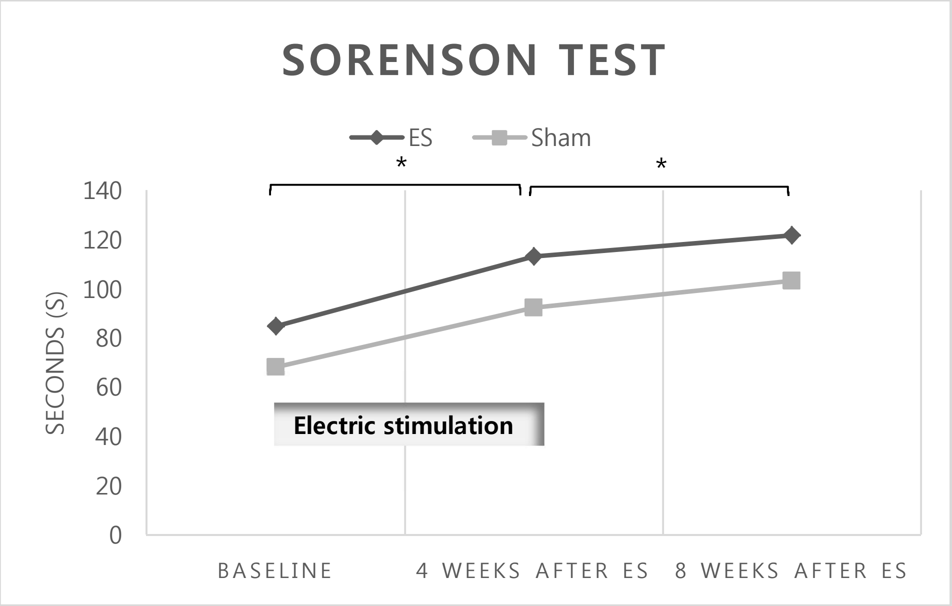

Figure 5. A RMANOVA for Sorenson endurance test (s) shows no significant interaction between time and intervention or intervention.

**: between-group differences *: within-group differences
ES: electrical stimulation; RMANOVA: repeated-measures analysis of variance

Table 2. Pain, fatigue score and mean stimulation intensity between ES group and control group

Group	ES group	Control	P-value
Pain (NRS)	2.38±2.14	0.48±0.69	0.001
Fatigue (NRS)	1.72±1.48	0.33±0.45	<0.001
Mean stimulation intensity (mA)	18.03±4.44	2.77±0.94	<0.001

Values are shown in mean ± standard deviation.

NRS: numeric rating score (NRS)

IV. Discussion

The present study demonstrated the short-term efficacy of ES during prolonged sitting. Just after 4 weeks of ES during sitting, the isokinetic extensor trunk muscle strength in the ES group measured at 120°/s angular velocity significantly increased ($P < 0.05$) compared with that in the control group. Therefore, ES performed in the sitting position could represent a much more accessible rehabilitation program for improving lumbar paraspinal muscle strength in individuals with a modern lifestyle or patients with acute back pain who are intolerant to exercise.

ES could help selectively train specific muscles such as the erector spinae muscle in patients with LBP. ES might also be much more advantageous for immobilized subjects who are unable to perform voluntary contractions. However, there are two major limitations of ES: intolerable discomfort, which is directly related to the current dose (18), and the restricted spatial recruitment of muscle fibers, which is relatively superficial and largely incomplete.(19)

The primary outcome of this study was the absolute peak torque in lumbar extension and flexion. Although it reflects only a fraction of the range of motion, the peak torque reflects the maximum output capacity of a muscle group and possesses intuitive value.

In this study, 60°/s and 120°/s were set in sequence. Regarding the reproducibility of isokinetic trunk strength measurement in flexion and extension, Baur et al. reported excellent reliability (intraclass correlation coefficient, 0.74–0.91) for different testing velocities (60°/s and 120°/s) in trunk flexion/extension in 20 healthy adults. The velocity of 60°/s is usually selected as the initial velocity due to the average force needed. Also, this seemed optimal for adjustment to the test. The velocity of 120°/s was set at the end because of less force needed and less fatigue, which possibly manifested by a repetition-related decrement.(20, 21)

A number of technical factors can influence muscle strength data, such as positioning and stabilization of the subjects' body, testing posture used by subjects, velocity of test movements, and types of contraction modes. Among them, test posture is one of the most significant factors affecting the measurement of trunk muscle strength. Sitting is currently one of the most common postures used during measurement. However, this result could rely on the position of the subjects' feet (i.e., whether their feet are free from contact with either the footrest or floor), because leg muscles such as the iliopsoas, quadriceps, hamstring, and calf can enhance trunk muscle strength. We tried to evaluate only the lumbar muscle with a dynamometer with the subjects’ feet remaining free.(22, 23)

Considering the microstructure of the paraspinal muscle, a few studies have reported that a large proportion (54–73%) of slow-twitch fibers (type I) in healthy individuals sustain the postural role of the paraspinal muscles. There is a significant sex difference in paraspinal muscle fiber size, and the relative area of muscle occupied by type I fibers is larger in women than in men. This explains the better performance of women on paraspinal muscle endurance tests.(24) An increase in the proportion of type I fibers with advancing age has also been reported.(25) Differences in muscle fiber type distribution between the multifidus and the longissimus/iliocostalis muscles and between the thoracic and the lumbar segments remain controversial.(26) Type I fibers in the paraspinal muscles are larger than those in other muscle groups.(27) Furthermore, different muscle fibers show different recruitment capability at lower angular velocity; both type I and II fibers can be activated maximally, whereas the slow-twitch type I fibers remain passive as angular velocity increases.(28) We hypothesize that both type I and type II fibers might be maximally activated at 60°/s, whereas type II fibers contribute much more to the highest peak torque value at 120°/s. As fast motor unit recruitment during ES is preferential, the strengthening effect of ES could be more obvious at 120°/s. Whether flexors or extensors are more affected in patients with LBP remains controversial. Grabiner and Jeziorowski compared several isokinetic variables between healthy subjects and subjects with LBP, and found that trunk extensor power was significantly different between the control and LBP groups.(29) Ripamonti et al reported that the lowest maximal isometric torque and calculated maximal velocity values in subjects with LPB appear to be due to a significant difference in the maximal torque for the extensor muscles, whereas it might be due to a lower velocity contraction for the flexor muscles.(30) Based on these results, a rehabilitation program should emphasize strength training for the extensor muscles. Therefore, we presumed that ES during sitting could be used to enhance extensor muscle strength.

Although no statistically significant difference between groups was observed for extension at 60°/s, flexion at 60°/s, and flexion at 120°/s, except for extension at 120°/s, there was significant effect of time at each test session in that subjects in both groups showed improvement just after the study or at 4 weeks after the study compared to baseline. It is assumed that ES can help straighten posture, which enhances core strength reciprocally.

Maintenance of the strengthening effect was relatively short (<1 month) in this study. However, McQuain, et al reported that the improvement of isometric back extensor strength was maintained with continued stimulation during the next 9 months.(17) One of the possible reasons for our result is the small number of total sessions used of this study.

This study has several limitations. As in many similar studies, one limitation was our small sample size, which might have contributed to the negative result of this study. The second limitation, a lack of reproducibility in strength measurements, may have arisen due to the subjects' position and fixation. Third, there is no consensus on the optimal parameters for ES for back muscle strengthening during sitting only.

In conclusion, ES during sitting is an effective and accessible rehabilitation program that can be used to improve the extensor trunk muscle strength of the lumbar paraspinal muscle, although the effect was short-term.

REFERENCES

1. Andersson GB. Epidemiological features of chronic low-back pain. Lancet. 1999;354(9178):581-5

2. Dankaerts W, O'Sullivan P, Burnett A, Straker L. Differences in sitting postures are associated with nonspecific chronic low back pain disorders when patients are subclassified. Spine. 2006;31(6):698-704.

3. Beach TA, Parkinson RJ, Stothart JP, Callaghan JP. Effects of prolonged sitting on the passive flexion stiffness of the in vivo lumbar spine. Spine J. 2005;5(2):145-54.

4. Fenety PA, Putnam C, Walker JM. In-chair movement: validity, reliability and implications for measuring sitting discomfort. Appl Ergon. 2000;31(4):383-93.

5. Gregory DE, Dunk NM, Callaghan JP. Stability ball versus office chair: comparison of muscle activation and lumbar spine posture during prolonged sitting. Hum Factors. 2006;48(1):142-53.

6. Corlett EN. Background to sitting at work: research-based requirements for the design of work seats. Ergonomics. 2006;49(14):1538-46.

7. Takemasa R, Yamamoto H, Tani T. Trunk muscle strength in and effect of trunk muscle exercises for patients with chronic low back pain. The differences in patients with and without organic lumbar lesions. Spine. 1995;20(23):2522-30.

8. Hides JA, Richardson CA, Jull GA. Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. Spine. 1996;21(23):2763-9.

9. Mannion AF. Fibre type characteristics and function of the human paraspinal muscles: normal values and changes in association with low back pain. J Electromyogr Kinesiol. 1999;9(6):363-77.

10. Alaranta H, Luoto S, Heliovaara M, Hurri H. Static back endurance and the risk of low-back pain. Clin Biomech (Bristol, Avon). 1995;10(6):323-4.

11. Kankaanpaa M, Taimela S, Airaksinen O, Hanninen O. The efficacy of active rehabilitation in chronic low back pain. Effect on pain intensity, self-experienced disability, and lumbar fatigability. Spine. 1999;24(10):1034-42.

12. Kahanovitz N, Nordin M, Verderame R, Yabut S, Parnianpour M, Viola K, et al. Normal trunk muscle strength and endurance in women and the effect of exercises and electrical stimulation. Part 2: Comparative analysis of electrical stimulation and exercises to increase trunk muscle strength and endurance. Spine. 1987;12(2):112-8.

13. Wright D, Barrow S, Fisher AD, Horsley SD, Jayson MI. Influence of physical,

psychological and behavioural factors on consultations for back pain. Br J Rheumatol. 1995;34(2):156-61.

14. Adamson J, Hunt K, Nazareth I. The influence of socio-demographic characteristics on consultation for back pain--a review of the literature. Fam Pract. 2011;28(2):163-71.

15. Filipovic A, Kleinoder H, Dormann U, Mester J. Electromyostimulation--a systematic review of the influence of training regimens and stimulation parameters on effectiveness in electromyostimulation training of selected strength parameters. J Strength Cond Res. 2011;25(11):3218-38.

16. Dreibati B, Lavet C, Pinti A, Poumarat G. Characterization of an electric stimulation protocol for muscular exercise. Ann Phys Rehabil Med. 2011;54(1):25-35.

17. McQuain MT, Sinaki M, Shibley LD, Wahner HW, Ilstrup DM. Effect of electrical stimulation on lumbar paraspinal muscles. Spine. 1993;18(13):1787-92.

18. Lake DA. Neuromuscular electrical stimulation. An overview and its application in the treatment of sports injuries. Sports Med. 1992;13(5):320-36.

19. Vanderthommen M, Duteil S, Wary C, Raynaud JS, Leroy-Willig A, Crielaard JM, et al. A comparison of voluntary and electrically induced contractions by interleaved 1H- and 31P-NMRS in humans. Journal of applied physiology (Bethesda, Md : 1985). 2003;94(3):1012-24.

20. Baur H, Muller S, Pilz F, Mayer P, Mayer F. Trunk extensor and flexor strength of long-distance race car drivers and physically active controls. J Sports Sci. 2010;28(11):1183-7.

21. Grabiner MD, Jeziorowski JJ. Isokinetic trunk extension and flexion strength-endurance relationships. Clin Biomech (Bristol, Avon). 1991;6(2):118-22.

22. Sapega AA. Muscle performance evaluation in orthopaedic practice. J Bone Joint Surg Am. 1990;72(10):1562-74.

23. Shirado O, Kaneda K, Ito T. Trunk-muscle strength during concentric and eccentric contraction: a comparison between healthy subjects and patients with chronic low-back pain. J Spinal Disord. 1992;5(2):175-82.

24. Mannion AF, Dumas GA, Stevenson JM, Cooper RG. The influence of muscle fiber size and type distribution on electromyographic measures of back muscle fatigability. Spine. 1998;23(5):576-84.

25. Mannion AF, Kaser L, Weber E, Rhyner A, Dvorak J, Muntener M. Influence of age and duration of symptoms on fibre type distribution and size of the back muscles in chronic low back pain patients. Eur Spine J. 2000;9(4):273-81.

26. Jorgensen K. Human trunk extensor muscles physiology and ergonomics. Acta Physiol

Scand Suppl. 1997;637:1-58.

27. Crossman K, Mahon M, Watson PJ, Oldham JA, Cooper RG. Chronic low back pain-associated paraspinal muscle dysfunction is not the result of a constitutionally determined "adverse" fiber-type composition. Spine. 2004;29(6):628-34.

28. Kannus P. Isokinetic evaluation of muscular performance: implications for muscle testing and rehabilitation. Int J Sports Med. 1994;15 Suppl 1:S11-8.

29. Grabiner MD, Jeziorowski JJ. Isokinetic trunk extension discriminates uninjured subjects from subjects with previous low back pain. Clin Biomech (Bristol, Avon). 1992;7(4):195-200.

30. Ripamonti M, Colin D, Rahmani A. Torque-velocity and power-velocity relationships during isokinetic trunk flexion and extension. Clin Biomech (Bristol, Avon). 2008;23(5):520-6.

국문 초록

서론: 체간 근육 약화는 요통의 위험 인자 중 하나에 속한다. 현대 사회의 주로 앉아서 지내는 생활방식은 체간 근육 약화를 유발할 수 있다. 허리 근력 강화 운동과 함께 요추 신전근에 전기 자극을 시행하였을 때 추가적인 근력 증강 효과를 얻을 수 있는 것으로 보고 된 바가 있다. 본 연구의 목적은 앉은 자세에서 요추 척추 주위 근에 전기 자극을 시행하여 근력 강화 효과를 평가하는 것이다.

방법: 30 명의 요통이 없는 건강한 성인을 대상으로 무작위 배정법을 통해 각 15명의 전기자극 그룹과 15명의 대조군으로 나누었다. 전기자극 그룹에서는 앉은 자세에서 피험자가 참을 수 있는 최대의 강도로 하루 60분 동안 주 3회, 4주 간 총 12회의 전기 자극을 요추 신전근에 시행하였다. 반면 대조군은 같은 방법으로 전기 자극을 하되, 감각 역치만 조금 넘는 상대적으로 낮은 강도로 전기 자극을 시행하였다. 요추 척추 주위근의 등속성 근력을 등운동성 동력계 (Biodex Medical dynamometer system-4) 을 이용하여 초당 60도, 120도를 각각 측정하였다. 초기 기저값, 4주간의 전기자극을 종료한 시점, 그리고 전기자극을 시작한지 8주가 지난 후 이렇게 총 3 시점에서 측정을 하였다.

결과: 4주 간의 앉은 자세에서의 전기자극 프로그램 종료 후 전기자극을 시행한 그룹에서 초당 120도의 체간 신전근의 등속성 근력이 대조군에 비해 유의하게 증가하였으나, 4주 간의 전기자극 실험 종료한 뒤 4주 이후에 재측정을 하였을 때 체간 신전근의 등속성 근력 증가의 효과가 유지되지 않았다.

결론: 앉은 자세에서의 전기 자극은 체간 신전근의 근력 증가에 효과가 있을 뿐만 아니라 접근성이 좋은 재활치료 프로그램의 일환이 될 수 있다. 그러나 체간 신전근의 근력 증가 효과가 단기간에만 유지된다는 한계가 있다.

주요어 : 요통, 전기자극, 등속성 근력

학 번 : 2013-22611