Journal of Back and Musculoskeletal Rehabilitation 28 (2015) 135–144
DOI 10.3233/BMR-140501
IOS Press


# Spinal postural training: Comparison of the postural and mobility effects of electrotherapy, exercise, biofeedback trainer in addition to postural education in university students

Şeyda Toprak Çelenay, Derya Özer Kaya* and Anıl Özüdoğru
*Ahi Evran University, School of Physical Therapy and Rehabilitation, Kırşehir, Turkey*



**Abstract.**
**BACKGROUND AND OBJECTIVE:** Spinal posture and mobility are significant for protecting spine. The aim was to compare effects of different postural training interventions on spinal posture and mobility.
**MATERIAL AND METHOD:** Ninety-six university students (ages: 18–25 years) were allocated into Electrical Stimulation (ES) ($n = 24$), Exercise ($n = 24$), Biofeedback Posture Trainer (Backtone) ($n = 24$), and Postural Education ($n = 24$, Controls) groups. All the groups got postural education. The interventions were carried out 3 days a week for 8 weeks. Spinal Mouse® device (Idiag, Fehraltorf, Switzerland) was used to detect thoracic and lumbar curvatures and mobility (degrees) in standing and sitting positions. Paired Student's t-test, one-way ANOVA, and pairwise post-hoc tests were used.
**RESULTS:** ES decreased thoracic curvature, the exercise decreased thoracic and lumbar curvature and increased thoracic mobility in standing position between pre-post training ($p < 0.05$). Exercise and Backtone improved thoracic curvature in sitting ($p < 0.05$). In Exercise Group, thoracic curvature decreased compared to Backtone and Education Groups, and thoracic mobility increased compared to all groups ($p < 0.05$).
**CONCLUSIONS:** The exercise was effective and superior in improving thoracic and lumbar curves, and mobility among university students. ES decreased thoracic curve. Biofeedback posture trainer improved sitting posture.
**LEVEL OF EVIDENCE:** A prospective randomized controlled trial, Level 1.

Keywords: Back posture, posture education, electrical stimulation, exercise, orthotic device

## 1. Introduction

The musculoskeletal spinal disorders have been considered as major health problems [1]. They were declared to trigger physical and psychological problems, generate disability, impair the quality of life, decrease manpower of the individual, and cause great economic costs [2,3]. The disorders were mostly associated with faulty back posture and lack of mobility as a cause or as a consequence [4–7]. In thoracic spine, kyphotic posture was declared to be the source of posture origined pain, lumbo-pelvic posture, decreased spinal extension mobility, spinal extensor muscle weakness, and sensory deficit [4,5,8,9]. Inactivity, non-ergonomic working or studying conditions and emotional stress were strongly associated with the problem [10,11]. Stand-

*Corresponding author: Derya Özer Kaya, Ahi Evran University, School of Physiotherapy and Rehabilitation, Kuşdili Mahallesi, Terme Caddesi, 40200 Kırşehir, Turkey. Tel.: +90 386 280 53 73, +90 532 715 82 20; Fax: +90 386 280 53 71; E-mail: deryaozer 2000@yahoo.com.

ISSN 1053-8127/15/$35.00 

ing and sitting positions in human subjects have been clearly documented to stress the spine [12–14]. Spending so much time on sitting postures during studying or daily living activities, computer usage for long time periods, inactive lifestyle, inadequate nutrition and stress turned out the young adult university students to be a risk group [15–17]. Revealing accurate strategies to protect public health especially in that risk group have been extremely significant.

Different interventions to protect and improve spine health in different populations were occurred in literature and in daily usage [18–20]. Postural education programs which were designed to provide information and advice have been commonly used [21]. However, contradictory results about the efficiency of the programs were published [22–25]. Some studies showed that electrical stimulation (ES) as a different intervention could change spinal posture and mobility as well as reducing pain, increasing muscle strength, decreasing joint stiffness and spasm in muscles [19,26,27]. Exercise approaches, especially spinal stabilization exercises have been popular for treating and preventing musculoskeletal spinal disorders, lately [28,29]. Previous studies relating to spinal stabilization exercises were investigated variable parameters such as postural stability, pain, function and spine mobility [20,30, 31]. However, effectiveness of the exercises on spine posture and mobility has not been well documented. Moreover, some orthotic and biofeedback trainer devices were introduced and commonly recommended to maintain upright posture, provide proprioceptive input, support trunk, prevent pain-producing events, ensure training of the necessary muscles [32–34]. However, it has not been clearly declared if the devices were more effective than other interventions for the treatment and prevention of spine posture and mobility.

Although many different interventions have been widely used in physiotherapy clinics, few studies were observed evaluating the effects of these programs on spinal posture and mobility, and no studies were detected comparing to each other [24,30,35]. Therefore, the aims of the current study were to investigate the effects of postural education on posture and mobility, and to assess and compare the effects of electrotherapy, exercise, biofeedback trainer in addition to postural education in university students. The following hypotheses were investigated: 1. Different postural training programs affect spinal posture and mobility in university students, 2. None of the different postural training programs has had superiority to each other.

## 2. Methods

### 2.1. Design

A prospective randomized, blind, controlled trial design was used. This study was conducted in accordance with the rules of the Declaration of Helsinki. Written informed consent was obtained from each participant. It was approved by the Human Research Ethics Committee of the University (Approval number: 12/12-1).

### 2.2. Participants

Healthy and voluntary participants aged between 18–25 years who had not performed any regular physical activity for at least one year were recruited. The total 125 numbers of university students were assessed. The employed exclusion criteria were as followed: (i) having a systemic pathology including inflammatory disease; (ii) having musculoskeletal injury, trauma, pathology or structural deformity related to spine and extremities; or (iii) having active intervention including corticosteroid or any medication in the last 3 months. One hundred and two volunteers out of 125 were eligible for the study.

### 2.3. Randomization

Prior to commencing the study, the volunteers were randomly divided into four groups: Group 1. Postural Education + Electrical Stimulation Group (ES), Group 2. Postural Education + Thoracic Spinal Stabilization Exercise Group (Exercise), Group 3. Postural Education + Biofeedback Trainer Device Group (Backtone), Group 4. Only Postural Education Group (Education). At the end of eight weeks, 96 participants (ES: $n = 24$, X $\pm$ SD: 19.66 $\pm$ 1.16 years; Exercise: $n = 24$, X $\pm$ SD: 21.00 $\pm$ 1.06 years; Backtone: $n = 24$, X $\pm$ SD: 19.95 $\pm$ 1.04 years; Education: $n = 24$, X $\pm$ SD: 20.08 $\pm$ 1.01 years) completed the study. Details of included and excluded subject numbers into the study through the final data analysis have been provided in Fig. 1 as flowchart.

### 2.4. Outcome measures

Assessments related to spine posture and mobility was applied previously to join the training program, after finishing the program at the $8^{\text{th}}$ week. All evaluations were conducted by the same physical therapists (AO), who used a standardized protocol to en-

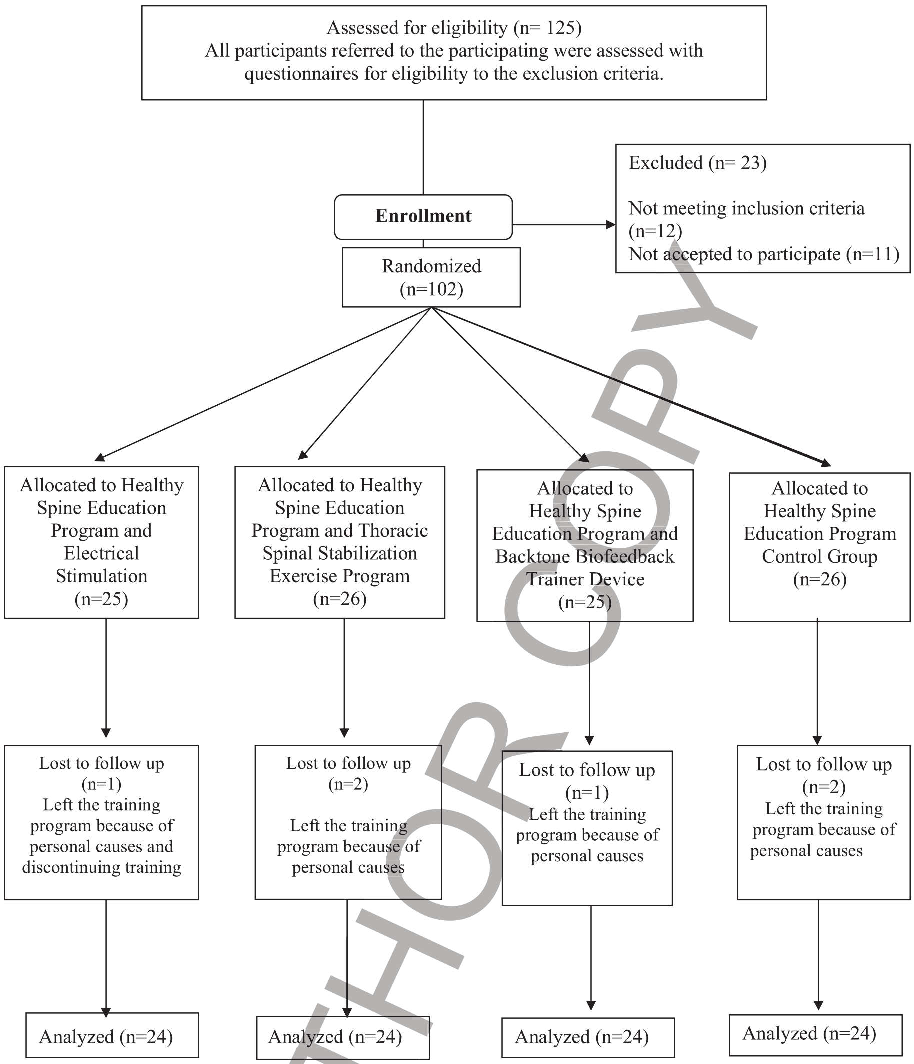



Fig. 1. The flowchart diagram for the participants.



sure the consistency of subject positioning, instructions, and overall testing procedures. The examiner himself was blinded to the groups' intervention. The physical characteristics including age, gender, exercise, smoking and drinking habits were recorded. Level of physical activity was assessed by the Turkish version of International Physical Activity Questionnaire-7 (IPAQ-7) [36]. Body composition was evaluated by Bodystat® 1500 Bio-impedance analyzers (Bodystat Ltd, Douglas, Isle of Man, UK).

Spinal posture and mobility were assessed using the Spinal Mouse® System (Idiag, Fehraltorf, Switzerland), a hand-held, computer-assisted electromechanical device. The intra-tester and inter-tester, and day-to-day reliability of the Spinal Mouse device had been published previously [37]. The bony landmarks were firstly determined by palpation and marked on the skin surface. A rolling sensor head followed the contour of the spine paravertebrally along the spine from the 7th cervical to the third sacral vertebra. This information was then used to calculate the relative positions of the spine using the software. Measurements were made during standing upright position, maximum flexion and maximum extension positions, respectively. All measurements were also repeated while the participant was seated on an armless chair first in an upright position, then maximally flexed and maximally extended. Thoracic curvature (T1-2 to T11-12), lumbar curvature (T12-L1 to the sacrum), thoracic and lumbar mobility were treated as outcome measures in degrees which

Fig. 2. Place of eight electrodes on back. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/BMR-140501)

were calculated by the software. Mobility results were calculated by examining the differences between maximum flexion and maximum extension end positions.

### 2.5. Interventions

After the baseline assessments all the groups had one session of postural education seminar by the experienced physical therapist (DOK). It included basic anatomy, physiology, and biomechanics of spine. Ideal posture characterized by a lack of upper trunk displacement, a "normal" lumbar lordosis and thoracic kyphosis and activation of deep muscles of the spine were mentioned [38,39]. The participants were practiced to control appropriate spinal curves one-by-one during standing and sitting and were asked to maintain the positions and contractions during daily activities as much as possible throughout the day. Education Group was treated as controls and followed by a timetable once a week to see how much they care about the postural positions.

ES was applied to the Group 1 by using muscular reinforcement program of Compex Device® (Compex 3 Professional, Compex Médical SA, Switzerland). The program was made up of three sequences of stimulation that automatically run on from one another: The first sequence consisted of a warm up of 2 minutes at a frequency of 6 Hz. The second was the work sequence including alternate contractions (75 Hz), and rest (4 Hz) which lasted 4 and 10 seconds, respectively. After the work sequence, the third part was relaxation (3 Hz) which lasted 3 minutes. Eight electrodes were placed on the middle trapezius muscles and T6-T12 levels over erector spine muscles bulks motor points in prone position (Fig. 2). The intensity of the current was arranged separately one by one for each participant until apparent muscle contraction was established (20–40 mA). They used it during 20 minutes for 3 days per week for 8 weeks.

Group 2 had Thoracic Spinal Stabilization Exercise program. Thoracic bracing technique with postural alignment and minimal multifidus muscle activation with scapular orientation for exercise group was performed [40]. The participants were asked to maintain the positions and contractions during the exercises. The exercise program were composed of 10 min-warm-up exercises, 20 min stabilization exercises, 10 min-cool-down, and stretching exercises in a group set-up. The progression included three phases according to the stages of motor learning and sensory motor integration as static, dynamic, and functional [41]. The static phase aimed to maintain short quick motor control and kinesthetic awareness. The exercises included workouts of thoracic bracing in neurodevelopment stages (supine, prone, side lying, quadripedal, bipedal). They held the contraction for 10 seconds at each position for 3 sets of 10 repetitions. Upper and lower extremity range of motion exercises were conducted while maintaining stabile spine at the specific positions. All exercise repetitions were increased progressively from 6 to 15. Dynamic phase's objective was to teach conscious motor control and to maintain stable spine during extremity motions with elastic resistive bands. It started at the third week and lasted at the end of $5^{th}$ week. The participants began exercises using the latex red band and a 200-cm-long precut section of Thera-Band® (Hygenic Corporation, Akron, OH) at medium tension. They had 10 repetitions of 3 sets each held for 6–10 seconds. When they performed 3 sets of 15 repetitions without significant pain or fatigue, they were progressed to the next color resistive band in the sequence of green, and blue. The functional phase aimed to teach unconscious motor control. The exercises included functional training with elastic resistance and exercise balls on unstable surfaces. They had 10 repetitions of 3 sets each held for 10–15 seconds. The intervention was carried out 8 weeks and 3 days/week.

Group 3 used BackTone® Biofeedback Posture Trainer (BackTone® 4000, BackTone Pty Ltd, Australia). It consisted of a light webbing harness with an electronic sensor. The electronic unit placed between shoulder blades and waist. As soon as individual sloucheed, the harness pulled on the sensor causing it to beep or vibrate. When straighten up, the beep stoped. Proper size of BackTone® was given to each participant. The participants were instructed how to apply it. They used it for 20 minutes for 3 days per week for 8 weeks.

### 2.6. *Statistical analysis*

The G*Power package software program (G*Power, Version 3.0.10, Franz Faul, Universität Kiel, German) was used to determine the sample size. It was calculated that a sample consisting of 24 subjects in each group, total 96 subjects was needed to obtain 90% power with $f = 0.40$ effect size, and $\alpha = 0.05$ type I error.

SPSS 11.5 for Windows (SPSS Inc. Chicago, IL, USA) was used for the outcomes. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogrov-Simirnov test) to determine whether or not they were normally distributed. Descriptive analyses were presented using mean and standard deviation (SD) for the normally distributed variables, and tables of frequencies for the ordinal variables. Paired Student's t-test was used to compare the measurements at the two time point (baseline and 8th week) for spinal posture and mobility. One-way ANOVA was used to compare spinal posture and mobility parameters among different postural training groups. Levene test was used to assess the homogeneity of the variances. An overall p-value of less than 0.05 was considered to show a statistically significant result. When an overall significance was observed, pairwise post-hoc tests were performed using Tukey's test.

## 3. Results

The baseline physical characteristics of the groups were displayed in Table 1. There were no statistical differences between the physical activity levels and body compositions of the groups ($p > 0.05$). The ages were different, but the range was so small clinically ($p < 0.05$). Descriptive findings of the participants were similar among groups. They were represented in Table 2.

At the beginning there were no differences between groups in standing and sitting for thoracic curvature, (standing; ES: 43.62 ± 1.63, Exercise: 43.33 ± 2.17, Backtone: 42.54 ± 2.02, Education: 39.50 ± 1.74; sitting; ES: 39.29 ± 1.43, Exercise: 35.08 ± 1.91, Backtone: 33.91 ± 2.12, Education: 31.29 ± 2.02), lumbar curvature (standing; ES: 26.58 ± 1.63, Exercise: 29.62 ± 1.24, Backtone: 25.66 ± 1.53, Education: 25.45 ± 1.00; sitting; ES: 1.08 ± 2.62, Exercise: 4.20 ± 1.96, Backtone: 6.04 ± 2.66, Education: 2.87 ± 2.05), thoracic mobility (standing; ES: 22.41 ± 2.75, Exercise: 18.75 ± 2.69, Backtone: 15.62 ± 4.04, Education: 27.50 ± 2.85; sitting; ES: 30.50 ± 4.01, Exercise: 32.66 ± 2.47, Backtone: 33.16 ± 3.60, Education: 39.00 ± 3.22), and lumbar mobility (standing; ES: 73.66 ± 2.77, Exercise: 72.37 ± 2.09, Backtone: 71.66 ± 2.38, Education: 75.87 ± 1.92; sitting; ES: 49.58 ± 2.97, Exercise: 54.12 ± 3.61, Backtone: 48.50 ± 4.44, Education: 52.54 ± 4.05); ($p > 0.05$). Thoracic curvature decline (Pre: 43.62 ± 1.63; Post: 37.01 ± 2.45) in ES Group, thoracic curvature (Pre: 43.33 ± 2.17; Post: 34.20 ± 2.11) and lumbar curvature decline (Pre: 29.62 ± 1.24; Post: 26.58 ± 1.49) and thoracic mobility increase (Pre: 18.75 ± 2.69; Post: 30.75 ± 1.56) in Exercise Group were found in standing between pre and post training ($p < 0.05$), (Fig. 3). Significant decline in thoracic curvature was also observed in sitting in favor of Exercise (Pre: 35.08 ± 1.91, Post: 31.29 ± 1.53) and Backtone groups (Pre: 33.91 ± 2.12; Post: 29.66 ± 2.35); ($p < 0.05$), (Fig. 4).

The intergroup comparison showed a significant difference in the thoracic curvature and mobility in standing among four groups ($p < 0.05$). Thoracic curvature decreased and thoracic mobility increased in Exercise Group in comparison to Backtone and Education groups ($p < 0.05$) (Table 3). Any difference in the lumbar curvature and mobility in standing and in the thoracic curvature, lumbar curvature, thoracic mobility and lumbar mobility in sitting could not be detected among four groups ($p > 0.05$).

## 4. Discussion

This study put forward the following outstanding findings: (i) Electrical stimulation decreased the thoracic curve in standing position, (ii) Exercise group showed the maximum decrease in thoracic and lumbar curvature, and increase in thoracic mobility in standing

Table 1
Physical characteristics of the participants

| Physical characteristics | Group 1 ES $n = 24$ X ± SD | Group 2 Exercise $n = 24$ X ± SD | Group 3 Biofeedback trainer device $n = 24$ X ± SD | Group 4 Education $n = 24$ X ± SD | p |
|---|---|---|---|---|---|
| Age (year) | 19.66 ± 1.16 | 21.00 ± 1.06 | 19.95 ± 1.04 | 20.08 ± 1.01 | $< 0.001^*$ |
| Fat mass (kg) | 12.79 ± 4.11 | 12.54 ± 5.49 | 12.56 ± 4.67 | 11.28 ± 4.66 | 0.542 |
| Lean mass (kg) | 54.33 ± 12.37 | 52.40 ± 11.64 | 50.21 ± 10.36 | 55.65 ± 12.90 | 0.441 |
| Body mass index (kg/m2) | 22.84 ± 3.15 | 22.50 ± 3.13 | 22.31 ± 2.27 | 22.72 ± 2.63 | 0.916 |
| Waist/hip ratio | 0.80 ± 0.07 | 0.82 ± 0.07 | 0.81 ± 0.06 | 0.82 ± 0.06 | 0.870 |
| IPAQ-7** | 1713.48 ± 1175.72 | 1788.46 ± 1185.14 | 2007.18 ± 1347.23 | 1849.79 ± 1520.23 | 0.889 |

$^*p < 0.05$; **IPAQ-7: International Physical Activity Questionnaire-7.

Table 2
Descriptive findings of the participants

| | | Group 1 ES n | % | Group 2 Exercise n | % | Group 3 Biofeedback trainer device n | % | Group 4 Education n | % |
|---|---|---|---|---|---|---|---|---|---|
| Gender | Female | 12 | 50.0 | 12 | 50.0 | 15 | 62.5 | 8 | 33.3 |
| | Male | 12 | 50.0 | 12 | 50.0 | 9 | 37.5 | 16 | 66.7 |
| Exercise habit | Yes | 21 | 87.5 | 21 | 87.5 | 14 | 58.3 | 19 | 79.2 |
| | No | 3 | 12.5 | 3 | 12.5 | 10 | 41.7 | 5 | 20.8 |
| Smoking | Yes | 3 | 12.5 | 0 | 0.0 | 2 | 8.3 | 8 | 33.3 |
| | No | 21 | 87.5 | 24 | 100.0 | 22 | 91.7 | 16 | 66.7 |
| Alcohol consumption | Yes | 1 | 4.2 | 0 | 0.0 | 1 | 4.2 | 2 | 8.3 |
| | No | 23 | 95.8 | 24 | 100.0 | 23 | 95.8 | 22 | 91.7 |
| Total | | 24 | 100.0 | 24 | 100.0 | 24 | 100.0 | 24 | 100.0 |

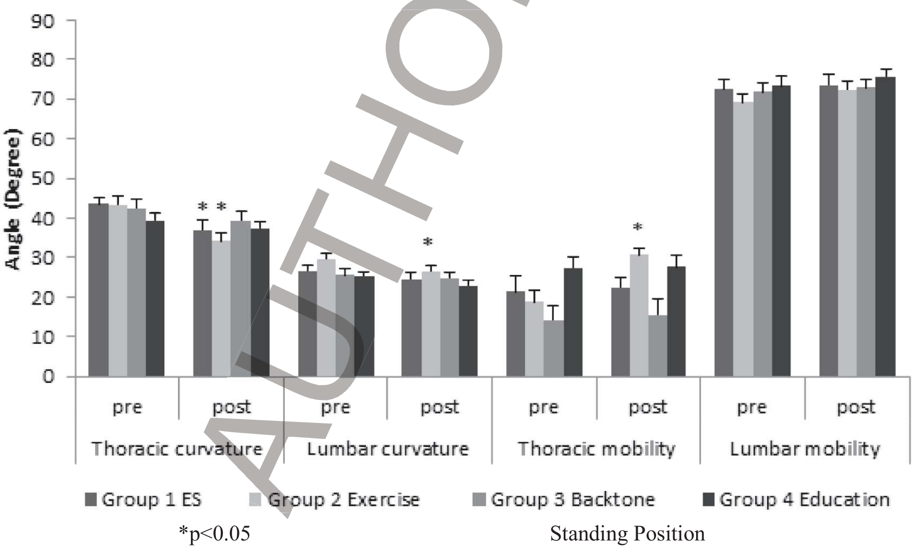



Fig. 3. Comparison of the thoracic curvature, lumbar curvature, thoracic mobility and lumbar mobility of groups' pre and post training.

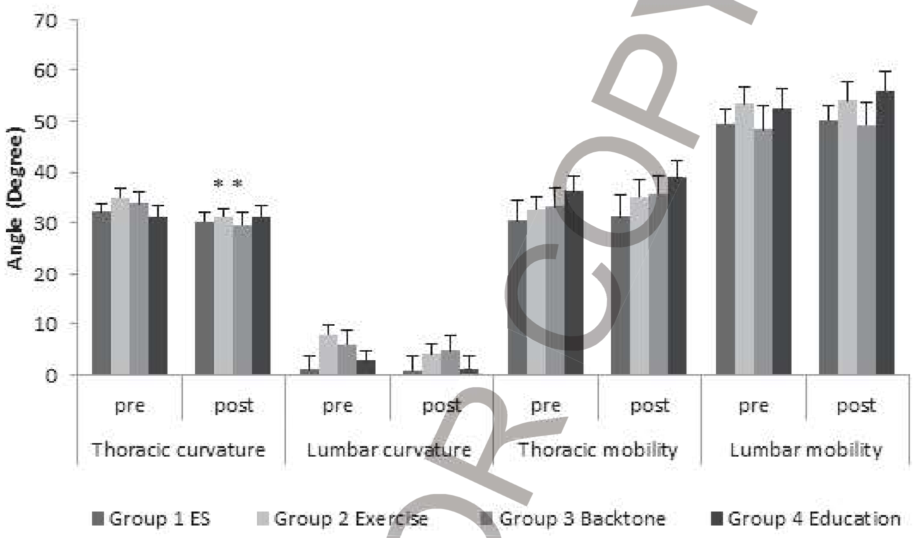
position, (iii) Backtone and Exercise Group indicated the maximum decrease in thoracic curvature in sitting position.

Posture was defined as the relative arrangement of the parts of the body [42] and spinal curvatures were used to identify ideal postures. The values proposed by Mejia et al. [43] for thoracic kyphosis. The degrees between 20 to 45 degrees were considered neutral in standing. Lower and higher values were classified as hypo and hyper kyphosis, respectively. Tüzün et al. [44] declared 20 to 40 degrees for lumbar lordosis as neutral in standing. Biomechanical evidence

Table 3
Differences between groups' pre and post training (baseline-8th week): Spinal Mouse results

| Parameters | Group 1 ES ($n = 24$) X ± SD | Group 2 Exercise ($n = 24$) X ± SD | Group 3 Biofeedback trainer device ($n = 24$) X ± SD | Group 4 Education ($n = 24$) X ± SD | p | Significant differences intergroup |
|---|---|---|---|---|---|---|
| Standing position 8th week-baseline differences | | | | | | |
| Thoracic curvature | −6.61 ± 8.59 | −9.12 ± 5.43 | −3.00 ± 8.91 | −2.08 ± 7.68 | 0.008* | Gr2>3>4* |
| Thoracic mobility | 1.12 ± 18.84 | 12.00 ± 12.32 | 1.37 ± 18.47 | 0.16 ± 10.10 | 0.008* | Gr2>3>1>4* |

$^*p < 0.05$. Gr: Group.




*p<0.05 Seating Position

Fig. 4. Comparison of the thoracic curvature, lumbar curvature, thoracic mobility and lumbar mobility of groups' pre and post training.



showed that increases in thoracic kyphosis were associated with significantly higher multi-segmental spinal loads and trunk muscle forces in upright stance. These factors were likely to accelerate degenerative processes in spinal motion segments and contribute to the development of dysfunction and pain [45].

The sitting positions in human subjects have also been clearly documented to assess the stress on spine posture and mobility as well as standing [12–14,46, 47]. It was reported that adolescents spend a lot of time in sitting, and those who spend more time in flexed or slumped positions report more thoracolumbar pain [48, 49]. In adults with low back pain, sitting was declared as a common aggravating factor [48,50] and accounted for significant disability [51,52]. For this reason, both standing and sitting postures were used to assess spinal posture and mobility in this study.

Postural education programs were the first step towards adopting healthy postural habits to prevent postural pain [53]. There was only one study investigating effects of postural education program on spine curvature [18]. Geldhof et al. [18] found that implementation of a back education program in elementary school children resulted in improved trunk muscle endurance, but there was no significant change in spinal curvature. Similar to this study, our results could not find any difference in spine curvature with just postural education. Moreover, any study which investigated the effects of postural education program on spinal mobility could not be detected. The current study did not show any difference in spinal mobility in postural education group. The reason of it might be related to the ineffectiveness of the education itself to change the posture.

Previous studies were revealed that ES decreased kyphosis and the Cobb angle, improved spinal alignment in sitting position in neurologic patients, and was beneficial for spinal mobility in the patients with chronic low back pain [26,46]. The results of this study showed decrease in thoracic curvature in standing position in healthy subjects. Using ES may improve postural alignment. It may be recommended for different musculoskeletal spine disorders for prevention and treatment in addition to postural education.

Exercise therapy were claimed to be effective in alleviating pain and disability as well as increasing spinal mobility, endurance, proprioception, and strength [35, 54]. In this study, spinal curvature and mobility for spinal function were taken into account. Thoracic Spinal Stabilization Exercise decreased thoracic and lumbar curvature in standing position, decreased thoracic curvature in sitting position, and increased thoracic mobility. Previous authors have postulated that abnormal kinematic behavior of the thoracic or lumbar spine was associated with back and low back pain and decreased mobility of the spine may lead to kyphosis and weakness of the paravertebral muscles, as well as impaired physical function [55–57]. Ball et al. [58] found that spinal extension exercises could delay the progression of kyphosis angle. Another study showed that Pilates-based exercise program observed small improvement in the thoracic kyphosis during standing [47]. Also, it was revealed that more neutral thoraco-lumbo-pelvic postures were associated with less back pain [59]. Therefore, our results support that Thoracic Spinal Stabilization Exercise is an important intervention for providing more neutral posture and could be useful for spinal disorders at clinics.

Biofeedback device was another intervention in this study. Previous studies showed that different bracing methods decreased thoracic kyphosis and improved postural alignment [60,61]. Moreover, there was only one study investigating effects of biofeedback device on spinal posture. Lou et al. [62] found that Spine-Straight device, a biofeedback device, could help to correct habitually poor posture, and improve spinal posture when feedback signals were provided. BackTone® device has highly been recommended by physical therapists as one of the most popular methods. However, no evidence about the effectiveness of such devices on spinal posture and mobility has been declared up to now. The results revealed that thoracic curvature decreased in subjects using BackTone® device in sitting position. Thus, this biofeedback device may be advised for people sitting for a long time at work in inappropriate positions.

The current study had some limitations. First of all, the study was conducted on healthy university students. Thus, the results could not be generalized for different age groups or pathologies. However, it might be a very good base for further studies on different populations, and groups. Secondly, despite the small range, the age difference between groups might cause limitation. Thirdly, although the training intensity, application frequency, time and duration arranged similar for each group, exercise group application might have been more intense in comparison to others. Moreover, the results of 8 weeks were represented in the study. Long term effects should be observed with longer follow-ups for the future studies.

## 5. Conclusion

Thoracic Spinal Stabilization Exercises were an effective and superior intervention on improving thoracic and lumbar spinal posture and mobility of university students. Electrical stimulation decreased thoracic curve, and Biofeedback Trainer Device improved sitting posture. However, postural education itself was effective to change neither spinal posture nor mobility.

## Acknowledgements

This study was funded by Ahi Evran University, Scientific Research Unit. (Foundation number: 47/2011-05). The authors would like to thank to the Scientific Research Unit of Ahi Evran University.

## References

[1] Hagen KB, Holte HH, Tambs K, Bjerkedal T. Socioeconomic factors and disability retirement from back pain. Spine (Phila Pa 1976). 2000; 25: 2480-7.

[2] Luo X, Pietrobon R, Sun SX, Liu GG, Hey L. Estimates and patterns of direct health care expenditures among individuals with back pain in the United States. Spine (PhilaPa 1976). 2004; 29(1): 79-86.

[3] Scholich SL, Hallner D, Wittenberg RH, Hasenbring MI, Rusu AC.The relationship between pain, disability, quality of life and cognitive-behavioral factors in chronic back pain. Disabil Rehabil. 2012; 34(23): 1993-2000.

[4] O'Sullivan PB, Grahamslaw KM, Kendell M, Lapenskie SC, Moller NE, Richards KV. The effect of different standing and sitting postures on trunk muscle activity in a pain-free population. Spine (PhilaPa 1976). 2002; 27: 1238-44.

[5] O'Sullivan PB, Mitchell T, Bulich P, Waller R, Holte J. The relationship between posture and back muscle endurance in industrial workers with flexion-related low back pain. Man Ther. 2006; 11(4): 264-71.

[6] Keller S, Mannion AF, Grob D. Reliability of a new measuring device ("Spinal Mouse") in recording the sagittal profile of the back. Eur Spine J. 2000; 9: 303.

[7] Digioia AM, Hafez MA, Jaramaz B, Levison TJ, Moody JE. Functional pelvic orientation measured from lateral standing and sitting radiographs. Clin Orthop. 2006; 453: 272-6.

[8] Hertling D, Kessler RM. Management of Common Musculoskeletal Disorders. In: Hertling D editor. The Thoracic Spine, Philedelphia: Lippincott Williams & Wilkins; 1996. p. 570-621.
[9] Katzman WB, Wanek L,Shepherd JA, Sellmeyer DE. Age-Related Hyperkyphosis: Its Causes, Consequences, and Management. J Orthop Sports Phys Ther. 2010; 40(6): 352-60.
[10] Ehrmann Feldman D, Shrier I, Rossignol M, Abenhaim L. Risk factors for the development of neck and upper limb pain in adolescents. Spine (PhilaPa 1976). 2002; 27: 523-8.
[11] O'Sullivan PB, Dankaerts W, Burnett AF, Farrell GT, Jefford E, Naylor CS, O'Sullivan KJ. Effect of different upright sitting postures on spinal curvature and trunk muscle activation in a pain free population. Spine (Phila Pa 1976). 2006; 31: 707-12.
[12] Shum GL, Crosbie J, Lee RY. Three-dimensional kinetics of the lumbar spine and hips in low back pain patients during sit-to-stand and stand-to-sit. Spine. 2007; 32: E211-9.
[13] Tully EA, Fotoohabadi MR, Galea MP. Sagittal spine and lower limb movement during sit-to-stand in healthy young subjects. Gait Posture. 2005; 22: 338-45.
[14] Lord MJ, Small JM, Dinsay JM, Watkins RG. Lumbar lordosis. Effects of sitting and standing. Spine. 1997; 22: 2571-4.
[15] Calvo-Muñoz I, Gómez-Conesa A, Sánchez-Meca J. Preventive physiotherapy interventions for back care in children and adolescents: a meta-analysis. BMC Musculoskelet Disord. 2012; 13(1): 152.
[16] Alricsson M, Landstad BJ, Romild U, Werner S. Self-Related Health, Physical Activity and Complaints in Swedish High School Students. The Scientific World Journal. 2006; 6: 816-26.
[17] Kneafsey R, Haigh C. Learning safe patient handling skills: Student nurse experiences of university and practice based education. Nurse Educ Today. 2007; 27: 832-39.
[18] Geldhof E, Cardon G, De Bourdeaudhuij I, Danneels L, Coorevits P, Vanderstraeten G, et al. Effects of back posture education on elementary schoolchildren's back function. Eur Spine J. 2007; 16(6): 829-39.
[19] Triolo RJ, Boggs L, Miller ME, Nemunaitis G, Nagy J, Bailey SN. Implanted electrical stimulation of the trunk for seated postural stability and function after cervical spinal cord injury: A single case study. Arch Phys Med. 2009; 90(2): 340-7.
[20] Granacher U, Lacroix A, Muehlbauer T, Roettger K, Gollhofer A. Effects of core instability strength training on trunk muscle strength, spinal mobility, dynamic balance and functional mobility in older adults. Gerontology. 2013; 59(2): 105-13.
[21] Burton AK, Waddell G, Tillotson KM, Summerton N. Information and advice to patients with back pain can have a positive effect: A randomized controlled trial of a novel educational booklet in primary care. Spine. 1999; 24: 2484-91.
[22] Haldeman S, Kopansky-Giles D, Hurwitz EL, Hoy D, Mark Erwin W, Dagenais S, et al. Advancements in the management of spine disorders. Best Pract Res Clin Rheumatol. 2012; 26(2): 263-80.
[23] Geldhof E, Cardon G, De Bourdeaudhuij I, De Clercq, D. Effects of a two-school-year multifactorial back education program in elementary school children. Spine (PhilaPa 1976). 2006; 31(17): 1965-73.
[24] Oleske DM, Lavender SA, Andersson GB, Kwasny MM. Are back supports plus education more effective than education alone in promoting recovery from low back pain? Results from a randomized clinical trial. Spine Pa 1976). 2007; 32(19): 2050-7.
[25] Van MN,Koes BW, Van derPloeg T, Smid T, Bouter LM. Lumbar supports and education for the prevention of low back pain in industry: A randomized controlled trial. JAMA. 1998; 279(22): 1789-94.
[26] Durmus D, Durmaz Y, Canturk F. Effects of therapeutic ultrasound and electrical stimulation program on pain, trunk muscle strength, disability, walking performance, quality of life, and depression in patients with low back pain: A randomized-controlled trial. Rheumatol Int. 2010; 30: 901-10.
[27] Karabay I, Dogan A, Arslan MD, Dost G, Ozgirgin N. Effects of functional electrical stimulationon trunk control in children with diplegic. Disabil Rehabil. 2012; 34(11): 965-70.
[28] Jull GA, Richardson CA. Motor control problems in patients with spinal pain: A new direction for therapeutic exercise. J Manipulative Physiol Ther. 2000; 23(2): 115-7.
[29] Reeves NP, Narendra KS, Cholewicki J. Spine stability: the six blind men and the elephant. Clin Biomech (Bristol, Avon). 2007; 22(3): 266-74.
[30] França FR, Burke TN, Hanada ES, Marques AP. Segmental stabilization and muscular strengthening in chronic low back pain - a comparative study. Clinics (Sao Paulo). 2010; 65(10): 1013-7.
[31] Kaya DO, Ergun N, Hayran M. Effectsof different segmental spinal stabilization protocolson postural stabilityin asymptomatic subjects: randomized controlled trial. J Back Musculoskelet Rehabil. 2012; 25(2): 109-16.
[32] Sinaki M, Brey RH, Hughes CA, Larson DR, Kaufman KR. Significant reduction in risk of falls and back pain in osteoporotic-kyphotic women through a Spinal Proprioceptive Extension ExerciseDynamic (SPEED) program. Mayo Clin Proc. 2005; 80: 849-55.
[33] Pfeifer M, Begerow B, Minne HW. Effects of a new spinal orthosis on posture, trunk strength, and quality of life in women withpostmenopausal osteoporosis: A randomized trial. Am J Phys Med Rehabil. 2004; 83: 177-186.
[34] Raikova R, Tahtakov K, Chakarov V. Technical device for prevention of spinal column disorders. Pilot EMG study for estimation of back muscle activity. Int J Bioautomation. 2011; 15(2): 115-130.
[35] Rainville J, Hartigan C, Martinez E, Limke JJouve C, Finno M. Exercise as a treatment for chronic low back pain. Spine J. 2004; 4: 106-15.
[36] Saglam M, Arikan H, Savci S, et al. International physical activity questionnaire: reliability and validity of theTurkish version. Percept Mot Skills. 2010; 111(1): 278-84.
[37] Mannion AF, Knecht K, Balaban G, Dvorak J, Grob D. A new skin surface device for measuring the curvature, and global and segmental ranges of motion of the spine: reliability of measurements and comparison with data reviewed from the literature. Eur Spine J. 2004; 13: 122-136.
[38] McKenzie RA. The Lumbar Spine: Mechanical Diagnosis and Therapy ed. Waikanae, NZ: Spinal Publications; 1981.
[39] O'Sullivan PB. 'Clinical instability of the lumbar spine: its pathological basis, diagnosis and conservative management. In: J. Boyling, G. Jull, eds. Grieve's Modern Manual Therapy. 3 ed. Singapore: Churchill Livingstone; 2004.
[40] Mottram SL, Woledge RC, Morrissey D. Motion analysis study of a scapular orientation exercise and subjects' ability to learn the exercise. Man Ther. 2009; 14(1): 13-8.
[41] Page P. Sensorimotor training: A "global" approach for balance training. J Body Mov Ther. 2006; 10: 77-84.
[42] Kendall HO, Kendal FP, Boynton DA. Posture and pain. Philadelphia: Williams & Wilkins, 1952.
[43] Mejia EA, Hennrikus WL, Schwend RM, Emans JB. A

prospective evaluation of idiopathic left thoracic scoliosis with magnetic resonance imaging. J Pediatr Orthop. 1996; 16(3): 354-8.
[44] Tüzün C, Yorulmaz I, Cinda A, Vatan S. Low back pain and posture. Clin Rheumatol. 1999; 18(4): 308-12.
[45] Briggs AM, van Dieën JH, Wrigley TV, Greig AM, Phillips B, Lo SK, Bennell KL. Thoracic kyphosis affects spinal loads and trunk muscle force. Phys Ther. 2007; 87 (5): 595-607.
[46] Park ES, Park CI, Lee HJ, Cho YS. The effect of electrical stimulation on the trunk control in young children with spastic diplegic cerebral palsy. J Korean Med Sci. 2001; 16(3): 347-50.
[47] Kuo YL, Tully EA, Galea MP. Sagittal spinal posture after Pilates-based exercise in healthy older adults. Spine (PhilaPa 1976). 2009; 34(10): 1046-51.
[48] Geldhof E, De Clercq D, De Bourdeaudhuij I, et al. Classroom postures of 8-12 year old children. Ergonomics. 2007; 50: 1571-81.
[49] Murphy S, Buckle P, Stubbs D. Classroom posture and self-reported back and neck pain in schoolchildren. Appl Ergon. 2004; 35: 113-20.
[50] Balague F, Troussier B, Salminen JJ. Non-specific low back pain in children and adolescents: risk factors. Eur Spine J. 1999; 8: 429-38.
[51] Dankaerts W, O'Sullivan P, Burnett A, et al. Altered patterns of superficial trunk muscle activation during sitting in nonspecific chronic low back pain patients: Importance of subclassification. Spine. 2006; 31: 2017-23.
[52] Dankaerts W, O'Sullivan P, Burnett A, et al. Differences in sitting postures are associated with nonspecific chronic low back pain disorders when patients are subclassified. Spine. 2006; 31: 698-704.
[53] Foltran FA, Moreira RF, Komatsu MO, Falconi MF, Sato TO. Effects of an educational back care program on Brazilian school children's knowledge regarding back pain prevention. Rev Bras Fisioter. 2012; 16(2): 128-33.
[54] Liddle SD, Baxter GD, Gracey JH. Exercise and chronic low back pain: what works? Pain. 2004; 170: 176-190.
[55] Burger H, Van Daele PL, Grashuis K, et al. Vertebral deformities and functional impairment in men and women. J Bone Miner Res. 1997; 12: 152-7.
[56] Mayer TG, Robinson R, Pegues P, Kohles S, Gatchel RJ. Lumbar segmental rigidity: Can its identification with facet injections and stretching exercises be useful? Arch Phys Med Rehabil. 2000; 81: 1143-50.
[57] Panjabi MM. Clinical spinal instability and low back pain. J Electromyogr Kinesiol. 2003; 13: 371-79.
[58] Ball JM, Cagle P, Johnson BE, Lucasey C, Lukert BP. Spinal extension exercises prevent natural progression of kyphosis. Osteoporos Int. 2009; 20; 481-9.
[59] Smith A, O'Sullivan P, Straker L. Classification of sagittal thoraco-lumbo-pelvic alignment of the adolescent spine in standing and its relationship to low back pain. Spine Phila 1976). 2008; 33: 2101-7.
[60] Pfeifer M, Begerow B, Minne HW. Effects of a new spinal orthosis on posture, trunk strength, and quality of life in women with postmenopausal osteoporosis: A randomized trial. Am J Phys Med Rehabil. 2004; 83: 177-186.
[61] Vogt L, Hübscher M, Brettmann K, Banzer W, Fink M. Postural correction by osteoporosis orthesis (Osteo-med): A randomized, placebo-controlled trial. Prosthet Orthot Int. 2008; 32 (1): 103-110.
[62] Lou E, Raso J, Hill D, Durdle N, Moreau M. Spine-Straight device for the treatment of kyphosis. Stud Health Technol Inform. 2002; 91: 401-4.