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THE EFFECTS OF BACK EXTENSION TRAINING ON BACK MUSCLE STRENGTH AND SPINAL RANGE OF MOTION IN YOUNG FEMALES

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ABSTRACT: The objective of this study was to determine the effects of a 10-week dynamic back extension training programme and its effects on back muscle strength, back muscle endurance and spinal range of motion (ROM) for healthy young females. Seventy-three young females (age: 19.32±1.80 years, height: 158.89±4.71 cm, body weight: 55.67±6.30 kg) volunteered for the study. Prior to the training period, all participants completed anthropometric measurements, back muscle strength and endurance test, lateral bending and spinal ROM measurements. After measurements, the participants were divided into two groups. The exercise group (N:35) performed the dynamic back extension exercise 3 days per week for 10 weeks. The control group (N:38) did not participate in any type of exercise. The mixed design ANOVA (group x time) was used to determine the difference in pre- and post-training values. The present findings show that there were significant differences between pre-training and post-training values for back muscle strength and spinal ROM in the exercise group. Following the dynamic strength training programme, back muscle strength and spine ROM values except flexion of the lumbar 5-sacrum 1 (L5-S1) segment of the exercise group showed a significant increase when compared with the pre test values. The control group did not show any significant changes when compared with the pre-training values. The results demonstrate that the 10-week dynamic strength training programme was effective for spinal extension ROM and back muscle strength, but there was no change in back muscle endurance. In this context, this programme could potentially be used to prevent the decrease of spinal ROM as well as provide an increase in the fitness parameters of healthy individuals.

KEY WORDS: anthropometry, spinal ROM, back extension muscle training

INTRODUCTION

Low back pain (LBP) is one of the most common public health problems in modern industrialized societies. Many lumbar problems are muscular in origin and persons suffering from LBP often have weak lumbar muscles [14]. Many studies have suggested that improved strength and endurance of the back musculature could aid in the prevention and treatment of LBP [6].

The spine is a lever subjected to external loads created by the weight of the trunk and any object lifted, and the forces created by the various muscles and ligaments surrounding the spine [27]. The lumbar spine is a complex structure associated with intervertebral discs and many attached ligaments and muscles. Each of these components is fundamental for stability and movement [12].

Flexibility is the range of motion available in joints. It differs from person to person and from joint to joint [1,18]. In other words, having good ROM in spine flexion does not guarantee having good ROM in spine extension [19]. Spine ROM like other joints in adulthood is affected by some variables. For instance, many researchers found differences between the sexes, with most reporting low spinal flexibility values, especially lower spine extension ROM for women than for men [1,3,19,31].

Physical activities often require flexibility of spine [25] and various activities require the ability to bend or twist the spine in order to move the upper body. Because the neck, trunk, and pelvis structures form the supportive base from which movement of the limbs occurs, the ability to move the neck and trunk also should contribute to the ability to move the extremities [31]. Therefore, decreased spinal ROM may be a possible source of decline in physical capabilities [25] and it is commonly associated with low back complications [4,19]. Spinal extensions have the greatest decrease in females because of the weak back muscles. This is because back muscle strengthening training is often ignored or is used less in exercise programmes [20], whereas female muscle strength only increases from strength training because of the production of much smaller amounts of testosterone [11].

The back extensors are essential to lifting and bending activities. These muscles act both to extend the spine and to balance the flexion movement produced by the trunk and weight being lifted [28].

Muscular strength can be defined as the ability of a muscle or group of muscles to generate force and thus muscular strength is increased with strength training. For this reason, strength training is used in physical fitness and the prevention and rehabilitation of musculoskeletal injuries [16,34]. For instance, low back extensor muscle strength is an important factor for low back health and these muscle strength training programmes are used mainly for rehabilitation of the lower back, prevention of injury, and as a component of fitness training programmes to enhance performance levels [5,13,14,34], because it is known that many people with low back pain have got weak low back muscles [15].

A decrease of the lower back muscles' strength may decrease spine ROM through its effect on back pain or inactivity. Previous studies [4,22,30] have examined the effects of strength training in patients with low back pain. However, the effect of dynamic back muscle strength training which aims to avoid reduction of spine ROM in healthy individuals has not been studied. Furthermore, regular strength training for the lumbar muscles has applications for healthy individuals who may benefit from training by reducing the risk of LBP. The objective of this study was to determine the effects of a 10-week dynamic back extension training programme and its effects on back muscle strength, back muscle endurance and spinal ROM for healthy young females.

MATERIALS AND METHODS

Participants. Seventy-three female university students between the ages of 18 and 24 years with no history of back pain were recruited. Participants were volunteers and signed an institutionally approved informed consent statement. The study was approved by the Gaziantep Clinic Research and Ethics Committee. Following the initial measurement, they were randomly assigned to either the control group or the exercise group. The exercise group (N:35, age: 18.17±0.61 years, height: 159.80±5.37 cm, body weight: 55.55±6.20 kg) performed the back extension exercises on the floor three times a week for 10 weeks. The control group (N:38, age: 20.39±1.88 years, height: 158.05±3.89 cm, body weight: 55.78±6.48 kg) performed no training during the 10 weeks.

Anthropometric measurements: Height and body weight (BW) were measured to the nearest 0.1 cm and 0.1 kg, respectively. BMI was calculated as body weight (kg) divided by squared height (m^2). Waist circumference was measured midway between the lower rib margin and the superior anterior iliac spine. Hip circumference was taken at the widest point over the greater trochanters with a tape measure, waist/hip (W/H) ratio as waist circumference (cm) divided by hip circumference (cm).

FM measurement: Skinfold measurements were taken from three sites (triceps, thigh, and suprailiac) to the nearest 0.1 mm using a skinfold caliper (Harpenden, England) and standard methods. Estimates of percentage body fat were calculated according to the method suggested by Jackson et al. [16].

Body density = 1.09942 - (0.0009929 x (sum of triceps SF + thigh SF + suprailiac SF) + (0.0000023 x (sum of triceps SF + thigh SF + suprailiac SF)^2) - (0.0001392 x age)

Fat % = (4.95/body density)-4.5) x100

Maximum back strength measurement

The isometric strength of the back muscle was determined in standing position with a spring dynamometer (Takei, Japan). The participants stood on the platform with the knees fully extended and the trunk flexed about 30° forward. The hand bar was positioned across the thighs, and thereafter the participants pulled it straight upward using the back muscle. Three trials were allowed with a 1-minute rest between the trials and the best score of three trials was recorded in kilogram force [16].

Back extensor endurance test (Biering-Sorensen test)

The participants lay prone over the end of a treatment couch with the anterior superior iliac spine supported on the bench edge. Their ankles were fixed by the researcher. They maintained the horizontal position for as long as possible, beginning timing when the horizontal unsupported position was achieved and ending when they dropped below the horizontal plane. The duration of holding was measured in seconds [26].

Inclinometric measurement

The thoracic and lumbar spine ROM for flexion and extension were measured using a single inclinometer (bubble inclinometer, Fabrication Enterprises Inc., USA). These measurements have been shown to be highly reliable (ICC-0.87–0.95) [8]. Spine ROM measurements were taken first in neutral, then in maximum flexion (L5-S1 (lumbar 5-sacrum 1), and T12-L1 (thoracic 12- lumbar 1) flexion, respectively), and finally in maximum extension positions (L5-S1, T12-L1 extension respectively). The spinous processes at L5-S1 and T12-L1 were located and marked by palpation with the participants standing upright. The inclinometer was placed on the landmark and „zeroed" before motion occurred. The participants performed flexion by bending forward as far as they could. They were instructed to keep their knees extended throughout the movement. Once full flexion was achieved and the inclinometer was read, the participants returned to the starting position. During the extension movement, the inclinometer was placed on L5-S1 and T12-L1 and 'zeroed' prior to performance of the extension movement. The participants performed extension by bending backward as far as they could. Once the full extension movement was completed, the inclinometer was read and the participant returned to the starting position.

Two practice movements were performed, and then two ROM measurements were recorded and averaged.

Lateral bending measurements

The distance between the tip of the middle finger and the floor was measured (in centimetres) in standing (start position) and in fully attained lateral bending position using a tape measure. The difference between these two measurements was the lateral bending ROM measurement for that side. Right lateral bending and left lateral bending were measured [9].

No warming up or stretching exercises were performed by the participants prior to the measurements and training, to eliminate the positive effects of warming up and stretching, except for back strength measurement. Before the maximum back strength measurement, 10 minutes of warm-up exercises were performed to minimise potential injuries. All measurements were performed by a sports scientist.

After all measurements had been completed, the participants were randomly assigned to either the control group or the exercise group.

Dynamic back extension training

The exercise group performed dynamic back extension training 4 times per week for 10 weeks. In this study, the exercise group exercised at approximately 80% of their previously determined maximal repeat values. This number was on average 25 repeats. Training consisted of 2 sets of 25 repetitions. The participants lay in a prone position on a mat with the knees fully extended and the toes pointed down to the floor. They clasped the hands behind the head and extended the torso to lift the chest off the floor. After completing the extension, the chest was allowed to lower and return to the starting position. The participants rested for at least 2 minute between sets [29].

All participants were re-tested after the 10 weeks using the same procedures described for the pre-test. All measurements were carried out in the same time interval (between 1:00 pm and 2:00 pm) and under the same environmental conditions.

Since the study concerned only the effect of back muscle strength training, the exercise programme contained no other physical activities.

Statistical analysis

For statistical analysis, SPSS 16.0 software was used. Means and standard deviations were calculated for the pre-test and post-test measurements for each group. The normality of distributions and the homogeneity of variances were assessed by Shapiro–Wilk and Levene tests. A mixed design ANOVA (group x time) was used to determine if there were any between or within group pre- and post-training differences in spinal ROM, back muscle strength and back muscle endurance measurement. The level of significance was set at $p<0.05$ for hypothesis testing.

RESULTS

In this study, both the control and exercise groups had similar body compositions to prevent the measured parameters being affected by the participants' anthropometric measurements. The means and standard deviations for physical characteristics and anthropometric measurements according to groups are presented in Table 1. The two groups were similar with regard to most of the baseline characteristics except for age ($p<0.05$). The results of some parameters, such as BMI, W/H ratio and FM (%), demonstrated that the participants have normal weight range and normal body fat. The lateral bending values of the two groups were similar.

The means, SD and changes in back muscle strength and back extensor muscle endurance are presented in Table 2. There were differences between groups for back muscle strength and back extensor endurance values before training. But after training, pre-training and post-training values of each group were compared separately. The subjects in the exercise group were instructed to perform the exercise three times per week for 10 weeks. After the training programme, the exercise group had a 21% increase in back muscle strength and there was a significant difference between pre- and post-training groups in terms of strength parameter. Endurance of the back muscles increased by only 0.25% (pre: 239.85 s, post: 240.45 s) in the exercise group, but decreased by 8.87% (pre: 187.58 s, post: 170.93 s) in the control group.

TABLE 1. CHARACTERISTICS OF CONTROL AND EXERCISE GROUPS

Parameters	Exercise Group (n=35)	Control Group (n=38)
Age (year)	18.17 ± 0.61*	20.39 ± 1.88
Height (cm)	159.80 ± 5.37	158.05 ± 3.89
BW (kg)	55.55 ± 6.20	55.78 ± 6.48
BMI (kg / m2)	21.77 ± 2.43	22.31 ± 2.22
Waist Circumference (cm)	70.08 ± 5.21	69.05 ± 4.90
Hip Circumference (cm)	94.05 ± 6.44	94.10 ± 5.34
W/H Ratio	0.74 ± 0.02	0.73 ± 0.03
FM (%)	25.35 ± 4.98	26.85 ± 5.87
FFM (kg)	41.27 ± 3.55	40.55 ± 3.23
Lateral Flexion (cm) - Left	21.17 ± 3.45	21.18 ± 4.13
Lateral Flexion (cm) - Right	20.35 ± 3.53	20.47 ± 3.77

Note: Data are means ± SD, * $p<0.05$.

TABLE 2. VALUES OF FITNESS PARAMETERS OF THE PARTICIPANTS

	Exercise Group (n=35)		Control Group (n=38)	
Fitness Parameters	Pre	Post	Pre	Post
Back Muscle Strength Test (kgf)	57.95 ± 11.21	70.12 ± 13.69*	70.71 ± 9.81	72.63 ± 10.18
Back Extensor Endurance Test (sec)	239.85 ± 81.68	240.46 ± 88.31	187.58 ± 81.16	171.08 ± 63.44

Note: Data are means ± SD, * $p<0.05$.

TABLE 3. MEASUREMENT OF SPINAL ROM OF THE PARTICIPANTS

	Exercise Group (n=35)		Control Group (n=38)	
Fitness Parameters	Pre	Post	Pre	Post
L5 - S1 Flexion	61.62 ± 7.72	64.68 ± 8.87	62.63 ± 14.6	63.13 ± 14.76
L5 - S1 Extension	24.14 ± 6.63	30.11 ± 6.55*	26.52 ± 8.09	27.76 ± 6.75
T12 - L1 Flexion	97.71 ± 10.13	100.68 ± 8.86*	96.52 ± 14.45	94.89 ± 13.22
T12 - L1 Extension	44.94 ± 9.65	51.40 ± 8.57*	45.84 ± 11.6	47.15 ± 9.42

Note: Data are means ± SD, * $p<0.05$.

Comparisons between the exercise and control groups of mean changes in pre- and post-training values for spinal ROM measurements are presented in Table 3. There were no differences between groups for spinal ROM values before training. But after training, the exercise group showed a significant improvement in extension ROM of the spine.

The mean positive changes for extension ROM of the L5-S1 segment, (24.73%) and T12-L1 segment (14.37%) were greater in the exercise group than in the control group. The changes of flexion ROM were only 4.96% and 3.03% in exercise groups. When we compared the two groups, there were significant differences for L5-S1 extension ROM, T12-L1 flexion ROM and T12-L1 extension ROM in the exercise group at the $p<0.05$ level between pre- and post-training values. No significant differences in mean changes in values were found at L5-S1 flexion when comparing the two measurements for the exercise group.

DISCUSSION

In this study, the spinal ROM and fitness parameters were measured before and after dynamic back muscle strength training. The 10-week strength training programme in this study resulted in significant increases in back muscle strength and extension ROM of the lumbar spine values when compared to the control group which performed no training. Several studies have examined the importance of stretching exercise, static exercise or isometric exercise for improving the spinal ROM [4,6,30,33]. The back extensor muscles, especially the erector spinae group, provide posterior stability for the vertebral column [2] and according to several studies there was a significant relationship between decreasing strength and endurance of these muscles and back pain. And also back pain was prevented by strengthening of these muscles [21,30].

The oblique muscles function mainly as a stabilizer of the coronal plane during lateral flexion activities [2]. As shown in Table 1, the right and left lateral flexion at the coronal plane were measured and it was found that there were only minor differences between the left and right bending values, which is approximately 1 cm, in both groups. When these results were examined, some of the participants had similar right and left bending values, but the others had approximately 7 cm differences between sides. Ashmen et al. used the same measurement technique in female athletes [2]; also Chow et al. studied lower trunk muscle activity during different types of tennis services [8] and they found that the left flexion was greater than the right flexion. In this study, lateral flexion was measured to determine only general core flexibility fitness, and therefore the influence of exercise was not examined. However, the difference between the right and left may also be explained by hand or side dominance in daily activities [2].

No differences were observed in back muscle endurance of the exercise and control group before and after training. This finding is consistent with previous studies in the literature documenting no improvement in back muscle endurance following isometric back muscle strength training in healthy participants [7]. This result may be related to which type of exercise is done, the sets and the repetitions. Perhaps positive changes in back muscle endurance could be found if the training programme involved a longer duration of training.

However, there was found a mean increase of 21% after the strength training of the back extensor muscles and this improvement was significant. Improvements of approximately 30 kilogram force (kgf) in the back muscle strength was observed in some participants after training. This finding is consistent with previous reports in the literature [16,23,20]. Some studies indicated that back muscle strength training increases muscle strength, muscle endurance and spine ROM in patients with chronic low back pain [6]. Graves et al. [15] reported 37% to 41% increases in strength in 12 weeks of lumbar extension strength training three times per week with the lumbar extension device. Lindström et al. [23] also reported significant increase in back muscle strength and spine ROM after progressive exercise in patients with acute low back pain. Elnaggar et al. [10] studied the effects of spinal flexion and spinal extension exercises in two different groups, and they found increasing ROM at the sagittal plane and decreasing low back pain.

This study showed a normal range of values of spine flexion and extension ROM [18] for each group before training. Our results showed that the exercise group was able to increase their extension ROM throughout the increased back extensor muscle strength. The exercise group also gained an average of 24.73% and 14.37% in the L5-S1 extension ROM and the T12-L1 extension ROM, but the control group gained only 2.79% and 2.85% extension ROM. These results showed that extension ROM of the L5-S1 segment had the greatest increase. Moreover, spine flexion ROM also had only a slight increase. The reason for the slight increase of flexion ROM may be explained by the dynamic type exercise. Allowing the participants to move their spine three times a week might have also increased their flexion ROM progressively.

Some studies have showed that increased muscle strength can cause increased ROM. Highland et al. [17] have reported significant increases in neck extensor muscle strength and extension ROM after isometric strength training. Our result may be related to the fact that strengthening the lumbar extensors pulled with great strength the vertebrae during the backward bending. It is thought that the same effects in patients with low back pain may be provided after this training.

CONCLUSIONS

In conclusion, this study investigated the effect of dynamic back muscle training on spine flexibility, as well as the back muscle strength and endurance in healthy females. It is known that inactivity decreases muscle strength and also results in decreased spinal flexibility and then decreased life quality. The results relating to ROM in patients with low back pain are in general agreement with other published studies [2,23,30]. The lack of time for planned exercise at fitness centres and expensive apparatus for home exercise are some of the excuses [24,32]. There are many exercises which improve quality of life and are easy to apply at home or a fitness centre. In this study, the results showed that doing dynamic back muscle strength exercise with a short duration of 10 weeks increased spine ROM and back muscle strength findings derived from the described applicable and useful exercise at home. Although the exercise in this study is not a planned and individual-specific programme, the results demonstrated that applied exercise prevents spinal ROM deterioration as well as improving these parameters. For this reason, prevention programmes for nonspecific low-back pain in sedentary adults and office workers should be directed at easy, cost-free and brief exercise at home.

Therefore, we suggest that future studies should evaluate the effectiveness of passive back muscle strength training and abdominal muscle strength training on healthy subjects and patients with chronic low back pain for the older ages, and, for future studies on osteoporosis prevention, whether applied exercise in this study with long-term participation causes an increase in spinal bone mineral density due to strength gain and muscle pull.

Conflict of interest: none declared

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