Improving the Outcomes after Back Injury by a Core Muscle Strengthening Program

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ABSTRACT

Back pain is a major healthcare problem in the United States. With medical reimbursements decreasing, any technique that will reduce costs and increase outcomes from physical therapy will benefit the 50% of the population with back pain. In the present investigation, 2 groups of male and female subjects were examined with non-specific low back pain and 2 groups were free of back pain. Subjects had back pain for at least 1 month. One group with back pain and one group free of back pain did nothing except receive measurements (the control groups). The other 2 groups, one with back pain and one without, exercised with a mini stability ball following exercise videos 3 days per week at home for 1 month (the active groups). The results showed that without physical therapy, there was a reduction in lower back pain (57% on physical movement of the lower back in extension and rotation and 54% on the Roland Morris back pain survey), an increase in range of motion before the onset of pain (5.78 degrees for extension, 5.5 degrees in left

Table 1. General Characteristics of Exercise Group (Mean and SD).

		Age (years)	Height (cm)	Weight (kg)	BMI (kg/m²)
Back pain exercise	Mean	41.6	165.4	84.2	30.9
	SD	13.6	11.1	26.9	9.6
Controls exercise	Mean	41.0	165.5	69.6	25.3
	SD	17.0	9.5	15.7	4.8

rotation and 5.6 degrees in right rotation of the hip), and an increase in core muscle strength (26.1%) in people with back pain who exercised. By a separate questionnaire, pain was reduced throughout the day and at night by 24% and 37%, respectively. The active exercise group (without pain) gained strength during the 1-month period. The other 2 non-exercising control groups showed no change in any parameter during the 1-month period. Thus the mini stability ball exercise program was very beneficial in increasing movement, reducing pain, and increasing strength.

INTRODUCTION

Lower and upper back injuries have always been a major problem in the United States and throughout the world.[1-4] Generally speaking, a first back injury occurs when people are in their twenties. In their thirties, back injuries do not usually reoccur.[5-7] However, by the time people are in their forties and fifties, the recurrence of back injuries is common.[8,9] These back injuries cost the American public billions of dollars each year in medical care and lost wages.[10] They are especially taxing on the workman's compensation system in that they commonly occur in the work environment.[11,12]

A variety of therapeutic treatments have been published in the past for back injuries. These include the McKenzie technique to allegedly force discs back into place,[13] sauna, hydrotherapy,[14] and core muscle strengthening.[15,16] In addition, back injury is usually treated with either non-steroidal anti-inflammatories or steroids to reduce inflammation and pain in tissue.[15] If severe enough, back surgery is indicated.[17]

Numerous studies have shown that strengthening the core muscles in the body reduces the chance of back injury.[1,2,18-20] Because these muscles are used to stabilize the trunk, strength in these muscle groups stabilizes the spine and balance. For this reason, the United States Army uses core muscle strength as predictors of back injury in recruits.[21] In addition, core muscle strengthening has been used in the treatment of recurrent back injury to allow healing to occur quicker and to prevent further injuries.[15,16]

While abdominal exercise has been shown to aid in the treatment or prevention of back injury in a clinic, unfortunately, in a therapeutic setting due to insurance restrictions, the amount of exercise that can be accomplished is very limited.[22-24] Therefore, because therapeutic exercise in a clinical setting is difficult to achieve for any extended period of time, it would be advantageous to include a home program of abdominal exercises that coincides with clinical treatment. The physical therapist could progress and critique the exercise program and focus on skilled clinical interventions and the patient can continue to exercise independently at home.

The standard for home abdominal exercise is typically abdominal crunches. Abdominal crunches suffer from 2 limitations: 1) the lower back is not stabilized such that rotation can be caused by

Table 2. General Characteristics of the Group Who Did Not Exercise (Mean SD).

		Age (years)	Height (cm)	Weight (kg)	BMI (kg/m²)
Pain	Mean	48.3	160.1	87.7	35.6
	SD	12.3	22.4	23.5	12.0
No pain	Mean	25.5	172.0	84.7	27.9
	SD	2.7	11.6	31.3	7.0

the exercise, which potentially could inflame the injury; and 2) the level of exercise is not very intense for strength training. Muscle activity is so low with abdominal crunch exercise that it is almost more suited for aerobic exercise then strengthening.

Recently, a new device was marketed called a mini stability ball. This 8-inch diameter inflatable stability ball allows someone to exercise in the home environment with high muscle use of the abdominal muscles (Savvier LP, Carlsbad, California). New exercises have been developed (The Bender Method for Core Training) for strengthening not only abdominal but lower back muscles, targeting lower back pain.

In the present investigation, groups of individuals with and without back injuries were studied for 1 month following a video exercise program incorporating the Bender Method with the mini stability ball. Clinical measures tested outcomes including a pain questionnaire, and resting muscle tone through an electromyogram with the back at various degrees of extension in both groups was used to assess the outcomes.

PATIENTS AND METHODS

Subjects

The subjects in the experiment were men and women (approximately equal men and women enrolled). All participants were screened by an intake form. Exclusion criteria included any person who had chronic low back pain associated with sciatica (pain going down one or both of the legs, neurological impairments from low back pain, or cardiovascular disorders). Subjects were excluded if they were pregnant. Inclusion criteria for subjects with back injury included non-specific low back pain that had existed for >4 weeks. Subjects were divided into 4 groups. Two groups, one with and one without back pain exercised 3 times a week for 1 month (active groups). The other 2 groups, one with and one without back pain participated in only the measurements for a period of 1 month (control groups). The exercise groups initially started with 20 people with back pain and 26 controls. All people without pain and 16 people with back pain finished the 1-month period. The main reason for the 4 drop-outs was fear of pain from the measuring sessions. The general characteristics of these 2 exercise groups are in Table 1. There were 25 subjects in the control group without pain and 16 in the control group with pain who did not exercise and whose characteristics are in Table 2.

All methods and procedures were explained to each subject who signed a statement of informed consent as approved by the institutional review board of Azusa Pacific University.

Measurement of Strength

Strength was measured with a modified exercise device. The device consisted of an abdominal crunch machine with strain gages added to measure the compression force (Figure 1). Subjects were asked to compress the device with their abdominal muscles while sitting straight

Figure 1. Measurement of strength in the rectus abdominus.

(rectus abdominus) or side bending left and right (obliques). Force was measured on 3 occasions with 1 minute between each measurement. The strength of each 3-second contraction was recorded on a Biopac MP100 system (Goleta, California) and the greatest strength in each direction was recorded as the maximum strength.

Mini Stability Ball Abdominal Exercises

Level 1. There were 3 exercises in Level 1. Subjects sat on the floor with the knees at 90 degrees and the hips initially at 110 degrees of flexion. The trunk was extended for the exercise and the mini stability ball was placed against the sacrum (about 16 cm in diameter placed at the mid sacrum) until, in different exercises, the back was extended to 60, 40, or 20 degrees. The back was held in place for 1 second and then flexed to the initial position. By extending the back by, for example, to 60 degrees from neutral, the angle at the back and hips was increased from 110 degrees of flexion to 60 degrees of extension or a total movement of 50 degrees. Thus the range of motion of the exercise was 50, 70, and 90 degrees for the 3 exercises. These exercises were repeated with the trunk rotated 35 degrees to the right and left to recruit the transverse abdominus and the obliques. During these exercises, the hands were placed under the knees for support. In the video tape program, it was explained that the user should always exercise at a range of motion that was challenging for the participant. This necessitated increasing range of motion during the exercises if they could each day.

Level 2. There were 5 exercises in Level 2. These consisted of first sitting on the floor with the knees at 90 degrees and the hips initially at 110 degrees of flexion. The hands were held in the air parallel to the floor. The back was resting against the mini stability ball, and the back was extended to 20, 40, or 60 degrees in different exercises, held for 1 second, and then returned back to the initial starting position. This exercise was repeated with the trunk rotated 35 degrees to the right and left to exercise the transverse abdominus and the obliques.

The final 2 exercises consisted of having the subject sit on the mini stability ball with the knees at 90 degrees and the hips at an angle of 90 degrees with the legs parallel to the floor. The legs were then alternatively extended to touch the floor with the toes pointed. The hands rested along the floor with the shoulder at 45 degrees for stability.

Level 3. There were 3 exercises in Level 3 accomplished to the right and left side

Table 3. Strength at the Onset and End of the Study in the Back Pain No Exercise Group.

		Right Oblique	Left Oblique	Rectus	Back Extensors
Pre	Mean	41.0	41.8	49.2	45.1
	SD	14.5	12.9	14.3	16.9
Post	Mean	41.5	42.2	49.8	46.5
	SD	14.2	13.0	14.3	16.9
t-test		>0.05	>0.05	>0.05	>0.05

of the body. The first exercise consisted of having the subject sit on the floor with the ball behind their back. Here the hips were at an angle of 110 degrees and the knees at 75 degrees. The hands were placed behind the head and as one leg was flexed, the opposite elbow touched the knee. This was done for one side of the body and then the other.

The second exercise was similar to the first but the movement was performed in rapid repetitions (pulsing). The third exercise set consisted of placing the hands on the floor with the shoulders abducted 45 degrees to the side of the body for support and placing the ball between the knees with the hips and knees at 90 degrees. The hips were slowly rotated to the right and then left through full range of motion.

Back exercises. The back exercises were a series of back extension exercises also using the mini stability ball. The warm-up involved placing the ball between the knees and rocking the hip into flexion and extension. This was followed by isometric co-contractions of the trunk extensors and flexors, alternatively contracting the upper and lower abdominals. The second warm-up exercise involved holding the ball and lifting it, and leaning forward and then side to side.

The first exercise involved arching the back from neutral to a round head up position. This was accomplished with the knees on the floor with hips at 90 degrees and the arms on the floor. This was used to exercise the abdominal muscles. This was accomplished with the hips in flexion. Next, in the same position, with the knees and hands on the floor and the back in neutral parallel to the floor, the hips were rotated such that the lower leg, one at a time, was rotated inward about 60 degrees. This was used to increase range of motion in the hip and lower back.

In the next exercise, subjects lay face down on the floor with their forehead on a pillow or towel. The abdominal muscles were then flexed to just lift the abdominals off of the floor. Now, with the head, shoulders and arms slightly off the floor and the arms extended at an angle of 90 degrees with respect to the body, the abdominals were again contracted as the arms went from a 90-degree angle through 45 degrees of rotation.

The person next changed to the seated position with the lower back leaning on the mini stability ball. With the knees at 90 degrees, the back was extended by about 45 degrees from the 90-degree hip position and then the subject returned back to the 90-degree hip, seated position.

With the person side lying on the floor, and the body weights supported on one arm bent at 90 degrees at the elbow, the hips were lifted off the floor alternatively until the body was straight in a side plank position. This was repeated on both sides.

Table 4. The Pain on Extension and Left and Right Rotation at the First Measurement and Second Measurement.

	Extension	Plus 5	Left Rotation	Plus 5	Right Rotation	Plus 5
First measurement						
Mean pain	3.5	4.7	2.1	3.0	3.6	4.3
SD	2.5	3.1	2.2	3.0	2.4	2.7
Mean angle	14.9	19.9	17.1	22.1	16.1	21.1
SD	7.7		7.9		7.7	
Second measurement						
Mean pain	3.8	4.6	2.3	2.8	3.5	4.3
SD	3.0	3.1	2.3	3.0	2.2	2.9
Mean angle	16.1	21.1	18.5	23.5	15.9	20.9
SD	10.1		5.2		6.8	

In another exercise, the person laid on their back with the mini stability ball directly under the tail bone. With the knees at an angle of 90 degrees and the feet flat on the floor, the hips were lifted alternatively and then shifted from side to side alternatively. Next, both legs were lifted such that the hip was at 90 degrees and the knee at 90 degrees. The toes were pointed. The feet were alternatively dropped to the floor with the knee extended to full extension and then returned to the initial position. Finally, with both knees elevated, the hips were flexed to bring the knees back to the chest.

Finally, with the subject side lying, the mini stability ball was placed under the ankles. The lower leg ankle remained on the ball and the upper leg was then lifted and moved 20 degrees forward, then the ankle was rotated down toward the floor and the floor was tapped. This was to exercise the gluteus maximus muscles. This was repeated on both sides. These were the major exercises on the back strengthening video tape.

Outcomes Analyzed in the Study

Quality-of-life outcomes analyzed in this study were from the Roland-Morris Back Pain Questionnaire.[25] The Roland-Morris Back Pain Questionnaire was chosen because it is one of the most frequently sighted and studied measures applied to patients with low back pain.[26] The Roland-Morris Back Pain Questionnaire consists of 24 items chosen from the sickness impact profile to cover a variety of activities of daily living. The Roland-Morris Back Pain Questionnaire was self-administered and took about 5 minutes to complete. Comparison studies and critical literature reviews suggest that the measurement properties of the Roland Morris Back Pain Questionnaire are equal to or better than those of other measures.[27-29] The Pearson correlation coefficients assessed at 3 weeks were 0.83 to 0.86.[27-29] Sensitivity to change, a form of validity, refers to the capacity of a measure to detect change from patient's functional status over time, and is distinguished between patients who change by differential amounts. The Roland-Morris Back Pain Questionnaire has been shown to be sensitive to change in patients with low back pain. A copy of the questionnaire is given below.[30]

For the measurement of onset of pain at different back extension angles, a Paris plinth was used to change the angle of the back for flexion and left and right rotation (Figure 2).

Name: **Date of Birth** **Date:**

When your back or leg hurts, you may find if difficult to do some of the things you normally do. Please mark with a cross only the sentences that describes you TODAY.

01. [ ] I stay at home most of the time because of my back and/or leg pain.
02. [ ] I walk more slowly than usual because of my back and/or leg pain.
03. [ ] Because of my back and/or leg pain, I am not doing any jobs that I usually do around the house.
04. [ ] Because of my back and/or leg pain, I use a handrail to get upstairs.
05. [ ] Because of my back and/or leg pain, I lie down to rest more often.
06. [ ] Because of my back and/or leg pain, I have to hold onto something to get out of an easy chair.
07. [ ] Because of my back and/or leg pain, I try to get other people to do things for me.
08. [ ] I get dressed more slowly than usual because of my back and/or leg pain.
09. [ ] I stand up only for short periods of time because of my back and/or leg pain.
10. [ ] Because of my back and/or leg pain, I try not to bend or kneel down.
11. [ ] I find it difficult to get out of a chair because of my back and/or leg pain.
12. [ ] My back is painful almost all of the time.
13. [ ] I find it difficult to turn over in bed because of my back and/or leg pain.
14. [ ] I have trouble putting on my socks (or stockings) because of pain in my back and/or leg pain.
15. [ ] I sleep less well because of my back and/or leg pain.
16. [ ] I avoid heavy jobs around the house because of my back and/or leg pain.
17. [ ] Because of back and/or leg pain, I am more irritable and bad tempered with people than usual.
18. [ ] Because of my back and/or leg pain, I go upstairs more slowly than usual.
19. [ ] I change positions frequently to try to get my back and /or leg comfortable.
20. [ ] My appetite is not very good because of my back and/or leg pain.
21. [ ] I can only walk short distances because of my back and/or leg pain.
22. [ ] Because of my back and/or leg pain, I get dressed with the help of someone else.
23. [ ] I sit down for most of the day because of my back and/or leg pain.
24. [ ] I stay in bed most of the time because of my back and/or leg pain.

Office Use Only Score: of 24

Roland-Morris Back Pain Questionnaire

The Roland-Morris Back Pain Questionnaire is a self-administered disability measure in which greater levels of disability are reflected by higher numbers on a 24-point scale. The Roland-Morris Back Pain Questionnaire has been shown to yield reliable measurements, which are valid for inferring the level of disability, and to be sensitive to change over time for groups of patients with low back pain. Little is known about the usefulness of this instrument in aiding decision making regarding individual patients.[30]

This questionnaire has been adapted to limit confusion by the patient with nerve root pain, who may have modest back pain.

To use, simply count the scores for a result between 0 and 24. Scores under 4 and over 20 may not show significant change over time in patients with scores of less than 4 and deterioration in patients who have scores greater than 20.[30]

Figure 2. Paris plinth.

Procedures
Four groups of subjects participated in the experiments. Each group of 25 subjects (2 with back pain and 2 without back pain) were examined at the beginning, at 2 weeks, and at 4 weeks. The measurements taken were: 1) range of motion; 2) strength for the rectus abdominus, left oblique, right oblique, and back extensor muscles; 3) Roland-Morris Back Pain Questionnaire; 4) angle for extension and left and right trunk rotation. Pain was felt for the back pain groups.

To measure pain on the Paris plinth, subjects lay prone on the plinth and the angle of the hip was changed until they just perceived pain for back extension and left and right hip rotation (Figure 2). This plinth angle was then extended an additional 5 degrees and a visual analogue scale used to measure pain. The plinth angle was then reduced by 10 degrees and the visual analogue pain scale was again used. Thus, 2 separate measures of pain were recorded, the angle at which pain first occurred, how much pain increased or decreased with an additional ± 5 degrees of movement of the trunk, and the measured angles. In addition, for the subjects who exercised, an additional questionnaire was filled out each day they exercised and included measures of how much pain they had in the morning, mid-day, and afternoon, how much they exercised with each of the tapes each day, and any change in activity.

Data Analysis
Data analysis involved the calculation of means, standard deviations, and *t*-tests. The level of significance was $P < 0.05$.

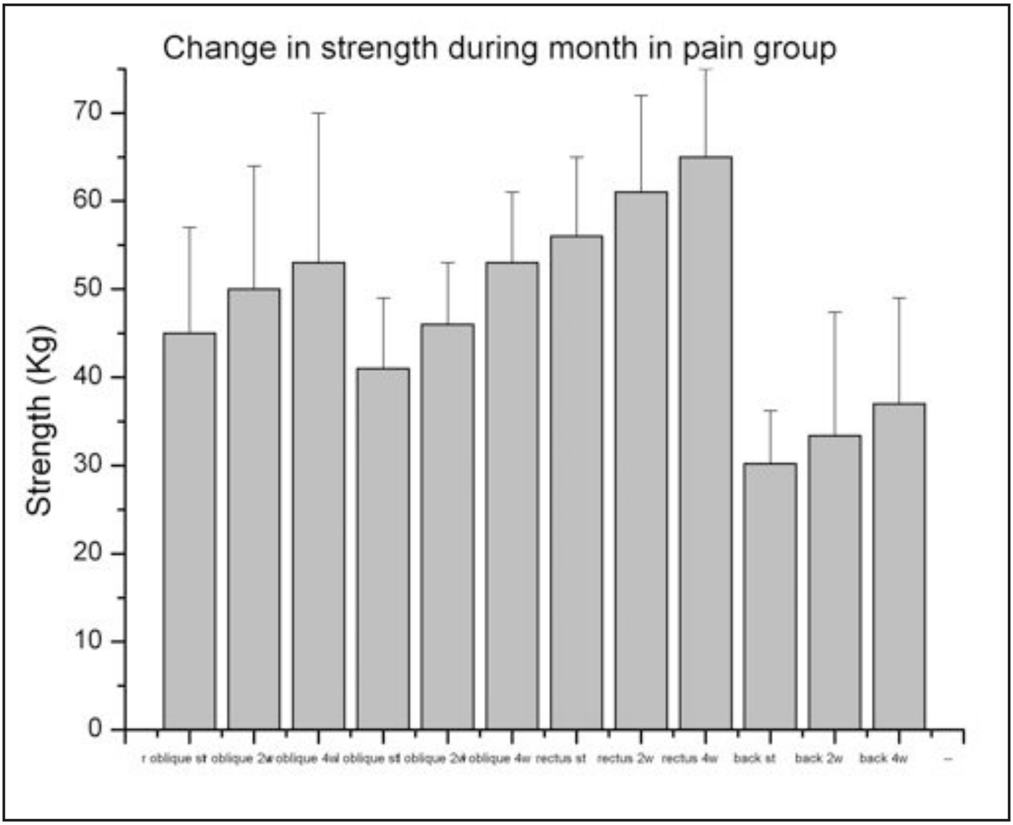

Figure 3. The muscle strength in the right and left oblique muscles, rectus abdominus, and back extensors at the onset (st), after 2 weeks (2w), and after 4 weeks (4w) of exercise in the back pain exercise group.

RESULTS

Back Pain Exercise Group

Compliance in this group was good. The average compliance was 79.1 ± 29.2% for watching and exercising to the abdominal video and 78.4 ± 22.7% for the back video. As shown in Figure 3, the muscle strength for the right and left obliques, rectus abdominus, and the back extensors all increased significantly at 2 and 4 weeks into the exercise program for the group with back pain who exercised with the videos. The increase in strength was significant (analysis of variance [ANOVA] $P < 0.05$).

Also shown in Figure 3, there was a significant increase in muscle strength throughout the month in each of the 3 muscle groups ($P < 0.01$). The increase in strength for the right and left obliques, rectus abdominus and the back extensors over the 1-month period was 27.4%, 36.8%, 22.3%, and 17.8%, respectively.

As shown in Figure 4, for each of the 3 measurements (back extension, left and right rotation), the angle at which pain first occurred increased over the 1-month period. The increase was seen at the 2-week period ($P < 0.05$) and was also significant at the 4-week period ($P < 0.05$). For back extension, the increase averaged 5.7 degrees without pain or an increase of 37% in back extension without pain. For left rotation, the angle at which pain occurred increased from 15.75 degrees to 21 degrees and for right rotation, the angle increased from 17.9 degrees to 21.6 degrees. These increases were also significant ($P < 0.05$). For the

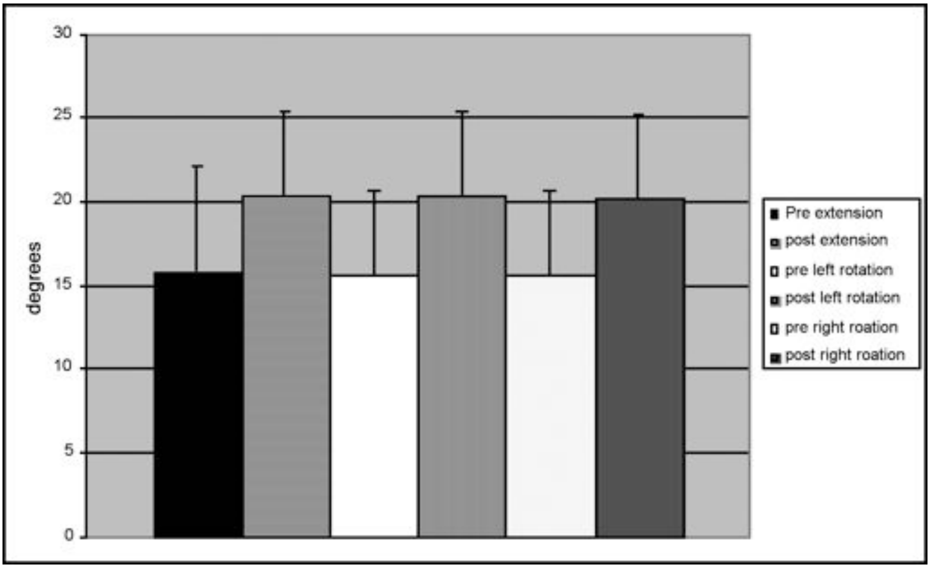

Figure 4. The angle of back extension or left or right rotation where pain started in the back pain group before and after the 1-month exercise period. Data is shown ± SD.

3 tests, the pain level at each of the 3 angles was 2.3 ± 1.7, 2.75 ± 1.8, and 2.5 ± 1.4 out of 10, respectively. After 1 month, pain at the greater angle was reduced significantly by 1.29, 0.95, and 1.25 out of 10. However, a more correct comparison would be to compare pain at the same angles. At the same angles, the pain pre-exercise was 2.75 ± 1.6, 3.05 ± 2.4, and 3.1 ± 2.5 out of 10. Thus pain was reduced by 62%, 49%, and 59%, respectiviely, for the 3 tests, or an average pain reduction at a given hip angle of 57%. This was paralleled in the Roland-Morris Back Pain Questionnaire where the score was reduced from 7.2 ± 3.2 to 4.4 ± 3.8, a statistically significant reduction ($P < 0.01$). Interestingly, the pain during the day, as assessed by a questionnaire, was 3.05 ± 1.6 during the day and 1.66 ± 0.7 during the night, and was reduced after the 1 month of exercise to 2.28 ± 0.38 and 1.03 ± 0.4 out of 10. This was a reduction in pain during the day and night of 24% and 37%, respectively.

No Back Pain Exercise Group

Compliance in this group was 78.1 ± 13.2% for exercising to the abdominal video and 81.4 ± 13.1% for the back video. As can be seen in Figure 5, muscle strength for the right and left obliques, rectus abdominus, and the back extensors all increased at 2 and 4 weeks into the exercise program. The increase in strength was significant (ANOVA $P < 0.05$). There was no back pain at any extension angle on this group who, by definition, had no back pain.

The increase in strength in this group was 15.6 ± 3.4%, 17.9 ± 4.3%, 12.9 ± 4.7%, and 13.7 ± 6.3% for the right and left obliques, rectus abdominus, and back extensors, respectively, over the 1-month period.

Back Pain No Exercise Group

The strength in the back injury group that did not exercise is shown in Table 3. As seen here, the strength did not change during the 1-month period for any muscle group examined.

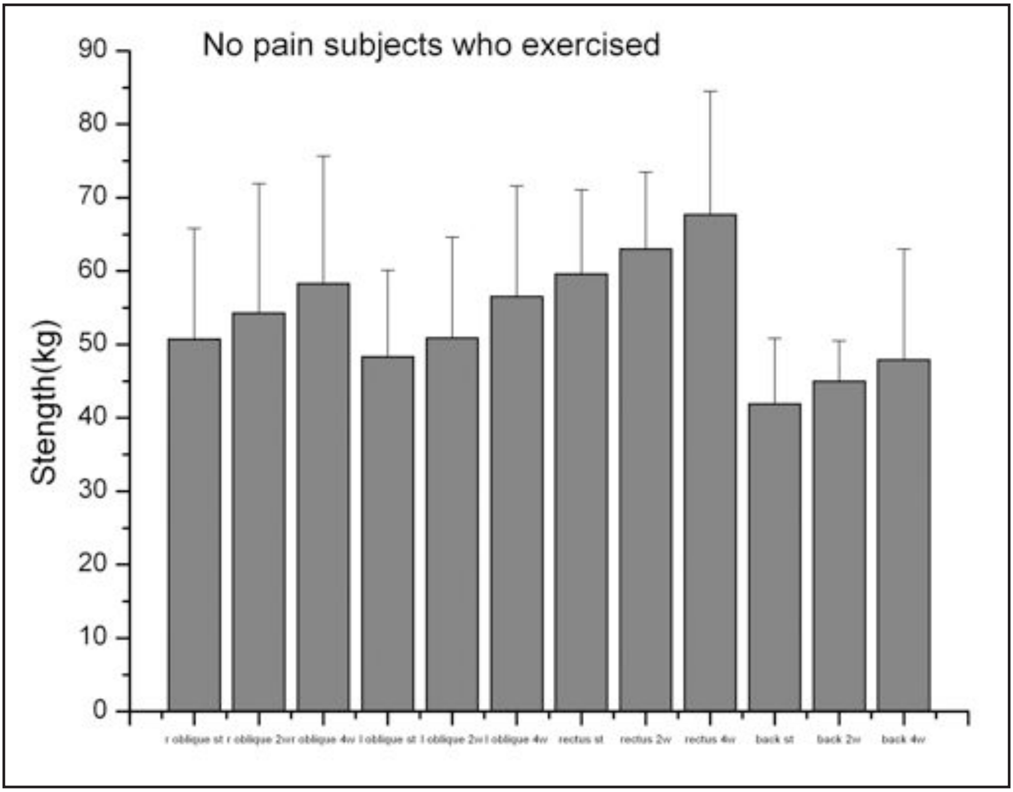

Figure 5. The muscle strength in the right and left oblique muscles, rectus abdominus, and back extensors at the onset (st), after 2 weeks (2w), and after 4 weeks (4w) of exercise in the no back pain exercise group.

The Roland-Morris Back Pain Questionnaire scores started at 8.0 ± 4.71 and ended at 8.21 ± 4.2. This difference was not significant ($P > 0.05$).

The pain on extension and left and right rotation is shown in Table 4. As shown here, the pain for left and right rotation and extension occurred at the same angle and same pain level before and after the 1-month period.

No Back Pain No Exercise Control Group

The group that did not exercise and did not have back pain had no statistical difference in their strength from the first to second set of measurements as shown in Figure 6 ($P > 0.05$).

DISCUSSION

Back injury has been a consistent problem in not only the American population but also other populations such as in Canada.[7,22-24] Back injury commonly occurs at a young age, when the body has the ability to heal (when someone is in their twenties).[8,9] However, when ageing reduces the ability of tissue to heal; back injury becomes a greater problem after the age of forty.[5-7] It is in this population in which the number of people is increasing the greatest. As the baby boomers age, more and more people are in the age range where back injury is a significant medical problem.

An additional complication is a cutback in Workman's Compensation System payments and private pay insurance. Due to budgetary issues in the last 10 years, both state and federal governments have cut back on insurance coverage for physical therapy.[24,31] This is also

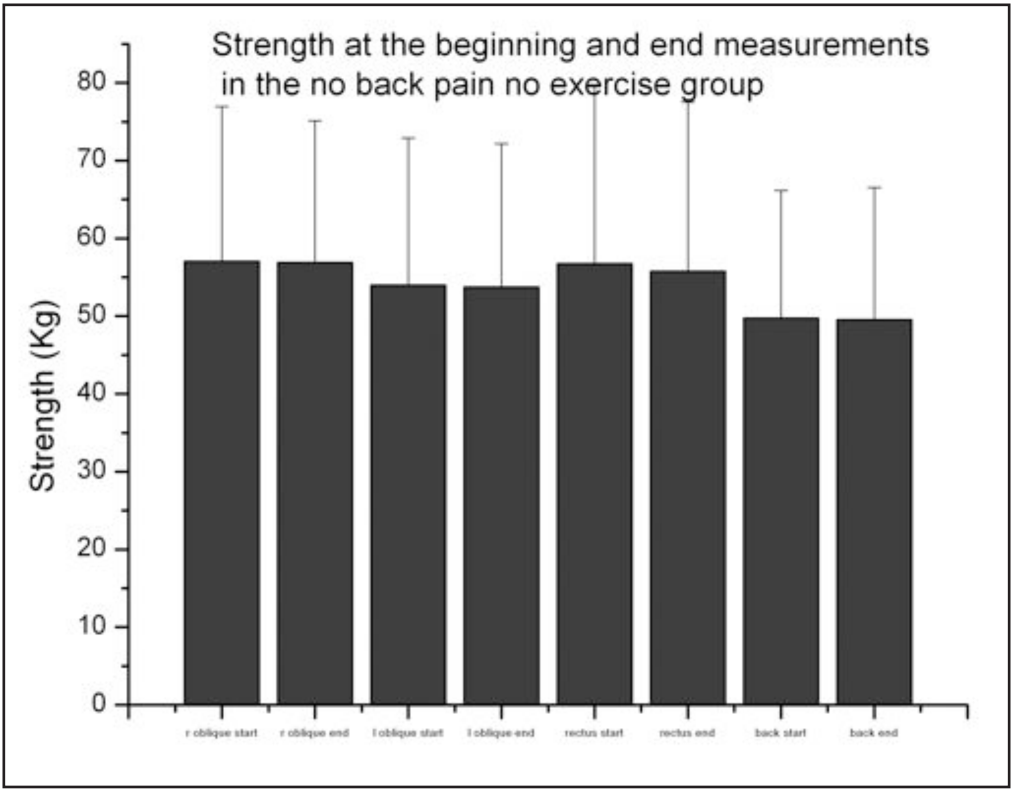

Figure 6. Strength pre and post in the no back pain no exercise group.

true of the Workman's Compensation System, especially in states like California. As such, diminishing physical therapy reimbursement is significantly reducing the number of visits allowed following back injuries, which not only can be debilitating and cause loss of work but also can cause additional paralysis. Thus, back injury can be quite serious and can result in even greater degrees of disability.[32]

Given all the above, there is a strong need for means of both preventing back injuries and treating back injuries more quickly. With physical therapy, a back injury treatment time has been reduced from an adequate number of sessions to adequately address the patient's impairments and functional limitations to just a few sessions under the modified Workman's Compensation System. Thus, any system that would increase the rate of recovery as well as prevent recurrent back injuries would be a strong aid to a very large existing health care problem.

In the present investigation, a set of exercises following the Bender Method of core training was accomplished on a mini stability ball used to train the abdominal core muscles and increase range of motion at the hips and lumbar spine. The results showed that with an abdominal core muscle home exercise program, there was a reduction in lower back pain (57% on physical movement of the lower back in extension and rotation and 54% on the Roland-Morris Back Pain Questionnaire), an increase in range of motion before the onset of pain (5.78 degrees for extension, 5.5 degrees in left rotation and 5.6 degrees in right rotation of the hip), and an increase in core muscle strength (26.1%) in people with back pain who exercised. Thus, the exercises were successful in building core strength and reducing pain.

It has been shown in numerous studies that there is a reduced incidence of back injury in children, adults, and older adults if the abdominal or core muscles of the body are strong.[18-21,33] Thus, the strength gains of core trunk musculature noted in this study should also prevent future and recurrence of back injuries. In conclusion, this home exercise video program was beneficial in increasing trunk movement and reducing lower back pain as well as increasing strength.

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