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The effect of Pilates exercises with and without antioxidants on pain, disability and endurance of flexor and extensor muscles in female teachers with non-specific chronic back pain

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***Abstract*— the aim of this study was to investigate the effect of Pilates training with and without consumption of antioxidants on pain, weakness and endurance of flexor and extensor muscles in female teachers with non-specific chronic back pain. The statistical sample of the research included 30 women suffering from non-specific chronic back pain purposefully selected and randomly assigned to three groups: Pilates without antioxidant, Pilates with antioxidant and control (10 people in each group). The intervention groups participated in a course of 8-week program, while the control group received no intervention and had their normal routine activities. The Pilates training protocol included six**

components: warming up, strengthening the abdominal muscles, control and excitability of the spine, lateral stabilization, shoulder stabilization and back strengthening, as well as hip stabilization and thigh endurance. Antioxidant consumption was in the form of daily consumption of one multi-daily capsule with a dose of 1000 micrograms. Before and after the intervention, the level of pain (Quebec Standard Pain Questionnaire), disability (Oswestry Disability Questionnaire) and endurance of flexor muscles (sit-up test) and trunk extensor (Sorenson test) were measured. Compared to the control group, both intervention groups caused a significant decrease in pain and disability and a significant increase in the endurance of trunk flexor and extensor muscles (P=0.001). These changes were significantly higher in the Pilates practice group with multi-daily consumption (P>0.05). Probably, Pilates improves pain and functional disability in teachers with non-specific chronic back pain by increasing trunk muscle endurance. For greater effect, it is better to use an antioxidant supplement (multi-daily) along with exercise.

***Keywords*— Back pain, Pilates, disability, trunk muscle endurance, female teachers**

Introduction

Work-related low back pain is the most common debilitating musculoskeletal injury in the world and can negatively affect working quality. Most of the medical costs are related to patients with chronic pain. This situation ultimately leads to reduced productivity and increased sick leave. Therefore, its economic dimension has drawn the attention of managers. So these people should quickly recover and return to work to prevent further economic loss (1-4).

Low back pain is more common in women than men (5) and is one of the most common reasons for absences from work and using health insurance and health services. According to the research, 70 to 85 percent of people have experienced back pain during their lives, and 80% of them have reported recurrence (6, 7). Because of the complexity of the mechanism of this type of pain, there is no proven method of treatment (8). Recent studies have shown that flexibility, strength, and endurance exercises, referred to as conventional methods of exercise therapy, are used to reduce pain and improve function in patients with chronic low back pain (9-11). The main causes of back pain are not clear yet but it seems that in most cases, back pain is caused by muscle weakness and awkward posture of the body (12). Research has shown changes in the degree of lumbar lordosis, abdominal muscle weakness, posterior lumbar muscle weakness, and loss of muscle endurance of thigh are the main factor contributing to low back pain (13, 14). The decrease in trunk muscle endurance is one of the most common findings in patients with back pain. Trunk flexor-extensor muscles are among postural muscles of body which act against gravity to keep the body in an upright position and control it when bending (15, 16).

According to many researchers, decreased endurance of these muscles leads to early fatigue, increased pressure, force on passive tissues of lumbar spine, damage to these tissues, and finally the incidence of low back pain (15-17). Similarly, the results of EMG tests prove increased muscle fatigue in people with low back pain compared to healthy individuals (18, 19). Farahpour e. al (2005) examined muscle endurance in patients with chronic low back pain and the changes in different modes of therapy and showed that patients with low back pain have significantly less strong trunk flexor-extensor muscles in the pre-test compared to normal individuals (17). Thinness and atrophy of trunk muscles in patients with low back pain compared to healthy individuals could be among the causes of lower muscular endurance in these people. Hides et al. (1994) showed in their study that in patients with low back pain, multifidus muscle cross-sectional area is 31% lower than in healthy individuals (20). Verbunt et al. (2003) also state that back muscles as postural and body maintenance muscles contract more than other muscles and are more prone to atrophy and weakness (21). So, it can be a cause of reduced endurance and fatigue of the muscles and the subsequent incidence of back pain and disability in such patients. Therefore, it can be helpful to enhance muscle endurance and delay the onset of fatigue. So far, several methods for the treatment of patients with chronic low back pain have been considered including using pain medication,

muscle relaxants, therapeutic yoga, stretching and flexibility exercises, stability exercises, massage therapy, and therapeutic exercise (13-22-25). Exercise therapy is a common practice in the treatment of patients with chronic low back pain (24, 26, 27). Hayden et al have found exercise therapy effective in the treatment of back pain (10). The importance of exercise in patients with low back pain is so considerable that different sport programs have been offered by researchers (10). Overall, the results show exercise therapy can reduce pain, increase muscle endurance, and improve the performance of patients with low back pain (28). By reviewing the literature of the studies on low back pain, it seems that in most studies, common exercises that can affect back pain are separately studied. Few studies have focused on a combination of several methods. Physiotherapy exercises have always been used for treatment. On the other hand, one of the methods of exercise therapy which in recent years has been widely paid attention to by exercise and rehabilitation specialists is Pilates (29). In this method, a set of special exercises are used that engage the body and the brain in a way that affect endurance, strength, and flexibility. This is done in static position (lying, sitting, and standing) and without moving, jumping or leaping. The advantage is that these exercises reduce the risk of joint injuries and muscle injuries (30). Many patients with back pain have found that Pilates can reduce their back pain, and prevent the disease recurrence. Despite the positive results of exercise therapy and different methods of it, few studies have been done on the effects of stabilization exercise with Pilates alone and in combination with other methods of treatment on non-specific chronic low back pain.

On the other hand, the consumption of antioxidant supplements has attracted the attention of many athletes and non-athletes with the goal of health. These supplements may also lead to improved pain in patients with low back pain. For this reason, the aim of this study was to investigate the effect of Pilates training with and without antioxidants on pain, weakness and endurance of flexor and extensor muscles in female teachers with non-specific chronic back pain.

Materials and methods

The current research was a clinical trial type.

The statistical sample of the research included 30 women suffering from non-specific chronic back pain purposefully selected and randomly assigned to three groups: Pilates without antioxidant, Pilates with antioxidant and control (10 people in each group). After the aim of the research and all the steps were described in details for the participants, all of them volunteered and completed a written consent form. Criteria for inclusion of patients in the study included being female, suffering from chronic non-specific low back pain, having low back pain of at least 3 months, a reduction in trunk flexor-extensor muscle endurance, and being aged between 20 and 45 years. Exclusion criteria included having acute and subacute low back pain, being pregnant, having a history of diseases, injuries and disorders affecting the underlying back pain such as a herniated disc, arthritis, sciatica, narrowing of vertebral canal, osteoporosis, the existence of bone Spurs in lumbar spine, hip and vertebral fractures, previous surgery, tumor, infection, ponytail syndrome, lumbar, scoliosis, flat back, kyphosis and history of any medication or health measures to remove low back pain. In addition, all the subjects were examined by a specialist, their MRI images were studied, and based on the criteria of inclusion they were homogenized.

The intervention groups participated in a course of 8-week program, while the control group received no intervention and had their normal routine activities. Pilates exercise protocol consisted of six components: warm-up, strengthening abdominal muscles, spine control and irritability, lateral stability, shoulder stability and strengthening the back, and pelvic stability and thigh strength. Before the start of training, the subjects were taught how to correctly inhale and exhale.

The number of times the exercises were repeated ranged between 6 and 10 and the exercises started from easy ones and gradually become more and more challenging, as the subjects become stronger (29).

Warm-up (7 to 10 minutes): sitting cat (6 to 10 reps) - mobilization of hip (6 to 10 reps) - floating foot (6 to 10 reps) - forming shoulder (6 to 10 reps) - raising chest by sit-ups (6 to 10 reps) - raising chest by sit-ups with pause (keep 6-esteem) - sliding two feet together (6 to 10 repeats) – hundred exercise (keeping the position for 6 to 10 breathing)
- Strengthening abdominal muscles: stretching one leg (6 to 10 reps) – diagonal sit-ups (6 to 10 reps) - pulling both feet (6 to 10 reps)
- Control and mobility of spinal cord: lifting hips off the floor (6 to 10 reps) - the mobility of spine (6 to 10 reps) - stretching the spine (6 to 10 reps) –
Lateral stability: lifting leg from the side (6 to 10 repetitions for each side) - lateral Kicking (6 to 10 repetitions for each side)
- Shoulder stability and strengthening back: Swimming in the squat (6 to 10 repetitions for each side) - Bump hips (6 to 10 repeats) - Practicing basic bed (6 to 10 reps) – back extension using hand (6 to 10 reps)
- Pelvic stability and hip endurance: Caterpillar for 5 seconds (6 to 10 repetitions for each side) - shell (6 to 10 reps)
Pilates exercise were a combination of physiotherapy exercises and Pilates as it is explained below. It was tried to keep the volume of interventions balanced, as far as possible.
- Warm-up (7 to 10 minutes): sitting Cat (6 to 10 reps) - mobilization of hip (6 to 10 repetitions) - forming shoulder (6 to 10 reps)
- raising chest by sit-ups with pause (keeping the position for up to 6 breaths)
- strengthening abdominal muscles: diagonal sit-ups (6 to 10 reps)
- Control and mobility of the spine: lifting hips off the floor (6 to 10 reps) - stretching the spine (6 to 10 repetitions)
- Lateral stability: lifting leg from the side (6 to 10 repetitions for each side) –
- Shoulder stability and strengthening back: Swimming in the squat (6 to 10 repetitions for each side) – back extension using hand (6 to 10 reps)
- Pelvic stability and hip endurance: shell (6 to 10 reps)
- pulling knees to the chest: they lying on the back and pulled one knee up into the abdomen, keep for six seconds, and then put the knee on the mattress. Then, the same was done with the other knee.
- Posterior pelvic tilt: they tilted their pelvis to the posterior and applied pressure on back arch for six seconds.
- Bridge: lying on their back, they raised their hips and held for six seconds
- Extension of back: they lied facedown with head and shoulders raised for six seconds on the mattress.
- Extension of the hip: they lied facedown with one leg straight up from the pelvic area and kept there for 7 seconds.
Antioxidant consumption was in the form of daily consumption of one multi-daily capsule with a dose of 1000 micrograms. 48 hours before and 48 hours after the intervention, the level of pain (Quebec Standard Pain Questionnaire), disability (Oswestry Disability Questionnaire) and endurance of flexor muscles (sit-up test) and trunk extensor (Sorenson test) were measured.
Quebec pain questionnaire consists of 25 five-item questions (minimum 0 and maximum 4) which scores the pain perceived while doing daily routines between 0 and 100. Scoring 0 implies complete health, 1-25 mild pain, 26-50 moderate pain, 51-75 strong pain, and 75-100 severe pain causing trouble for the patient (31). Oswestry questionnaire measures functional ability of patients by ten 6-option sections in the field of tolerance and coping with pain, personal care, lifting objects, walking, sitting, standing, sleeping, social life, travel, and change in the degree of pain. At worst disability conditions, score 5 is given to each section and the total score of the ten sections is 50. Total disability is obtained by multiplying the score in each section by 2. In fact, the range of scores is between 0 and 100. Thus, a score of zero indicates perfect health and a pain-free functionality, 1-25 mild disability, 26-50 moderate disability, 51-75 high disability, and 75-100 severe disability causing trouble for the patient (32). It should be noted that in this study, samples were selected among those who scored over 25 for pain and disability. Previous studies have approved and confirmed the validity and reliability of Quebec and Oswestry questionnaires to assess pain

and disability in daily activities and the reliability of them has been reported 84% (33). Sorenson test was used to assess the endurance of trunk extensor muscles. The subjects were asked to lie prostrate on the floor. Lower body was fixed by patches on the test bed while upper body was out of bed with hands in front of chest. Then, the subject was asked to keep the trunk without support horizontally until the signs of fatigue appeared. The time recorded was considered as the endurance of extensor muscles (34). The reliability and validity of this test have been verified to measure the endurance of extensor muscles and the reliability of it has been reported 88% in patients with nonspecific low back pain (88%) (35). In addition, in order to test trunk flexor muscle endurance sit-up test was used. The subjects lay on the back with the soles of the feet on the floor knees bent 90 degrees, and hands beside ears. The subject's legs were fixed on bed. The number of correct sit-ups done in one minute was recorded. The test is of high reliability. Its reliability has been reported 98% in different studies (36).

To analyze the data, descriptive and inferential statistics were used. In descriptive statistics, mean and standard deviation were used. In inferential statistics, In order to investigate and compare the changes of the variables, the statistical method of mixed variance analysis and Bonferroni post hoc test were used. The significant level was considered $P \leq 0.05$ and the SPSS software (version 16) was used to perform statistical operations.

Results

The results of mixed analysis of variance and Bonferroni post hoc test are presented in Tables 1 and 2, respectively.

Table1. The results of the mixed analysis of variance test

Variables	Groups	pre	post	F	P
Pain	Pilates	37.50 ± 11.77	19.80 ± 11.32	1178.63	0.001 *
	Pilates + Multi-daily	50 ± 7.43	28.10 ± 7.09		
	Control	45.50 ± 11.90	44.90 ± 11.43		
Disability	Pilates	53.10 ± 9.79	34.30 ± 9.83	825.79	0.001 *
	Pilates + Multi-daily	50.20 ± 5.30	28.60 ± 4.97		
	Control	51.90 ± 6.87	51.20 ± 7.71		
Endurance of flexor muscles	Pilates	11.40 ± 3.30	18.30 ± 3.40	904.07	0.001 *
	Pilates + Multi-daily	10.30 ± 3.65	18.80 ± 3.48		
	Control	9.70 ± 4.66	9.50 ± 4.14		
Endurance of extensor muscles	Pilates	19.90 ± 10.48	41.40 ± 12.28	255.72	0.001 *
	Pilates + Multi-daily	28.60 ± 11.67	55.30 ± 11.87		
	Control	27.50 ± 11.80	28.30 ± 12.79		

* Significant at the level of $P \leq 0.05$

Table2. Bonferroni post hoc test results

Variables	Pairwise comparison	P
Pain	Pilates / Pilates + Multi-daily	0.001 *
	Pilates / Control	0.001 *
	Pilates + Multi-daily / Control	0.001 *
Disability	Pilates / Pilates + Multi-daily	0.002 *
	Pilates / Control	0.001 *
	Pilates + Multi-daily / Control	0.001 *
Endurance of flexor muscles	Pilates / Pilates + Multi-daily	0.002 *
	Pilates / Control	0.001 *
	Pilates + Multi-daily / Control	0.001 *
Endurance of extensor muscles	Pilates / Pilates + Multi-daily	0.001 *
	Pilates / Control	0.001 *

	Pilates + Multi-daily / Control	0.001 *

* Significant at the level of P≤0.05

Compared to the control group, both intervention groups caused a significant decrease in pain and disability and a significant increase in the endurance of trunk flexor and extensor muscles (P=0.001). These changes were significantly higher in the Pilates practice group with multi-daily consumption (P>0.05).

Discussion

Based on the present findings, Pilates practice (both without multi-daily consumption and with multi-daily consumption) led to a significant decrease in pain and disability, and a significant increase in the endurance of trunk flexor and extensor muscles in female teachers with non-specific chronic back pain. These changes were significantly greater in the group that consumed multi-daily. Considering the impact of exercise on reducing pain and disability, the results of the present study are in line with the results of Barr (37). Previous research has showed that patients with chronic low back pain have weakness and atrophy of deep and central muscles, especially abdominal and multi-headed lumbar muscles (38). Also, it is aid that in patients with chronic low back pain, muscle dysfunction may be due to deformation and change of one of neuromuscular control mechanisms affecting trunk stability and efficiency in motion. Exercise may reduce pain and increase performance by increasing strength, endurance, flexibility, coordination, static and dynamic stability, neuromuscular control, motor control, correcting movement patterns and relaxation of muscles (37, 39). Pilates exercise probably control and develop sensory-motor trunk muscles and core muscles (40). The development of trunk stability decreases additional forces, which are harmful to the spine, and reduces pain. In addition, this exercise gives patients information about natural alignment of the spine, strengthens deep postural muscles that support this alignment, and reduces harmful pressure of passive spine holders. Mental practices of this method reduce the pressure on the body and increase concentration and muscle function during normal daily activities, so the pressure on the spine is reduced (41). The factors that lead to chronic back pain include reduction of strength, flexibility, and endurance of trunk muscles and excessive pressure imposed to the spine caused by bad body postures while sitting and standing. Pilates exercise strengthens deep back muscles like multifidus and transverse abdominal muscles. They also increase the coordination and development of trunk stability and reduce additional forces to the spine, which leads to lower back pain and physical disability. Pilates is a combination of static and dynamic stretching exercises to increase flexibility. Physiological neural properties of contractile tissues respond to stretching exercises. When performing stretching exercises of Pilates, soft tissues such as skin, tendon, joint capsule, and muscles cause the activation of Golgi tendon organ. These receptors control alpha motor neuron activity and thereby reduce muscle tension and allow sarcomere to be extended. Therefore, it seems that Pilates exercise can be used as a treatment method in patients with low back pain. Motealeh (2005) stated that endurance and coordination exercises and a combination of them improve pain and disability in patients with chronic low back pain and believes using a combination of endurance and coordination exercises is more effective in reducing pain and disability (42). Farahpour et al (2005) also pointed out that a 12-week physical therapy decreased the pain and disability of patients with chronic low back pain with the weakness of the flexor-extensor muscles of the trunk (17). However, the research done by Grifka (2006) reported contrasting results (43). That is probably because the sample and method of measuring the endurance of extensor muscles in work of Grifka is different from the present study as in study of Grifka, the sample consisted of 82 athletes with low back pain and surface electromyography was used to measure the endurance of extensor muscles (43). However, in the present study, the subjects were chosen from a non-athlete sample and Sorenson test was used to measure the endurance of extensor muscles. On the other hand, Rainville et al (2004) pointed out that there is no evidence that exercise therapy increases back pain or disability of patients and suggested that therapeutic exercise and endurance activities reduce the risk of injuries and lower back

pain. They believe these exercises can be used for treating patients as they increase the flexibility of muscles, improve their performance, and reduce pain (24).
Also, it was observed that the reduction of pain and disability and the increase of endurance of trunk flexor and extensor muscles were significantly increased due to the use of multi-daily. More studies should be done in this field, but it seems that one of the causes of pain in patients with back pain is increased oxidative stress and inflammation. For this reason, taking antioxidant supplements can reduce pain in these patients by reducing inflammation and oxidative stress. Reducing pain can lead to reduced disability and increased muscle function. In any case, more studies are needed in this field.

Conclusion

The nature of chronic back pain and the disability associated with it are influenced by several factors and it has been shown they are better perceived by psychosocial factors. Therefore, pain, and disability are the most important factors hindering success of the treatment of chronic low back pain. Studies have shown that movement therapy reduces pain and disability in patients with chronic low back pain follows. Several clinical studies have suggested this kind of treatment for chronic pain control. Based on the present results, we conclude that Pilates exercises (alone and with multi-daily consumption) increase the endurance capacity of the flexor and extensor muscles in creating stability and stability of the trunk and by raising the fatigue threshold of the trunk muscles, Improve pain and functional disability in working women with chronic non-specific low back pain.
Also, it seems that one of the causes of pain in patients with low back pain is increased oxidative stress and inflammation. For this reason, taking antioxidant supplements such as Multi-daily can reduce pain in these patients by reducing inflammation and oxidative stress and lead to reduced disability and increased muscle function. In any case, more studies are needed in this field.

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