Original Article

Modified Pilates versus general exercises effectiveness on lumbopelvic motor control, trunk muscles endurance, in nonspecific chronic low back pain women

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ABSTRACT

Background: Achieving a rehabilitation program to improve lumbar-pelvic motion control and trunk muscle endurance in patients with chronic low back pain has always been a concern for researchers and therapists. Therefore, the purpose of this study was to investigate the effect of modified Pilates exercises and general exercises on control of lumbar-pelvic motion and endurance of lower back and abdominal muscles in non-specific chronic low back pain women. Methods: In this randomized clinical trial study, 30 women with chronic non-specific chronic low back pain were selected through random sampling and randomly (consecutively) in two groups of Pilates exercises and general exercises. Lumbar-pelvic motion control index (compression biofeedback unit), muscle tardiness (Endurance test and Sorensen test), Pain score (Visual Analogue Scale) and functional disability score (Oswestry Low Back Pain Questioneare), before and after intervention were measured. Data were analyzed using Wilcoxon Signed Ranks Test and Mann-Whitney Test (P<0.05). Results: In the modified Pilates exercise group the lumbar-pelvic motion control index in the BKFO showed a significant change (P = 0.004). Abs and lumbar muscles endurance and pain score showed significant change (P = 0.001). There was no significant difference between the variables in the intergroup comparison (P> 0.05). Conclusion: The modified Pilates exercises were effective in increasing the level of muscle tolerance, control of lumbar-pelvic motion and reducing pain and disability. So Pilates exercises can be used in rehabilitation for patients with nonspecific chronic low back pain.

Keywords: Lumbar-pelvic motion control, modified Pilates exercises, non-specific chronic low back pain.

Introduction

Lumbar region is one the most commonly vulnerable sites of pain which has negative psychophysical effects on the sufferers [1]. The prevalence of low back pain has been significantly increased in industrial societies i.e. its immediate prevalence has been estimated at %14-16 in the US [2]. Chronic low back pain results in reduced muscular flexibility, poor spinal ROM, low muscular strength and endurance, and decreased spinal cord cross-sectional area [3], all of which will ultimately decline one's physical performance [3, 4].

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Spinal muscular atrophy and dysfunction may mitigate spinal force control and affect lumbopelvic stability [5]. According to Bergmark, spinal muscles are classified into two groups, namely deep/local muscles and superficial/global muscles [5]. Reduced strength and endurance of superficial muscles in the posterior lumbar region play a critical role in low back pain, implying that the endurance level of trunk extensor muscles is predictive of the first back pain attack [4, 6]. The deep global muscles have a crucial role not only in alleviating stress and decreasing spino-pelvic shear force but also in static and dynamic stability [7, 8]. Amongst deep muscles, the lumbar multifidus and transversus abdominis are accounted as the most important muscles strengthening the spinal stability [6, 9]. The main risk factors for chronic LBP include reduced motor control and weakness of such deep muscles as lumbar multifidus and Transverse abdominis [7, 9].

There are many therapeutic exercises for improving the spinal weakness, endurance and motor control [10-13]. As a rehabilitation intervention, Pilates exercise therapy involves improving the overall physical condition of the body aiming at raising body awareness and perfecting body posture [14-16]. Modified Pilates method is a comprehensive method of body-mind condition that is simultaneously associated with such workouts as trunk stability exercises, meditation, breathing technique and whole-body function [15, 16]. These training exercises put the emphasis on five essential principles, namely breathing technique, spinal alignment and posture, chest and scapular stability, neck movement and transvers abdominis muscle (TVA) activity [14, 15, 17]. During Pilates exercises, pelvic tilt is modified by the activation of pelvic floor muscles (diaphragm) and lumbopelvic stability is increased by the topical activation and co-contraction of trunk core muscles esp. transvers abdominis and multifidus, in the spinal cord [18, 19]. These trainings also feature low intensity, long-term and repetitive exercises contributing to the improvement of strength, endurance and neuromuscular control of the trunk muscles [20].

In a systematic study, Wells et al. (2014) investigated the effect of short-term Pilates exercises on pain relief and functional improvement in non-specific chronic LBP patients [18]. Klobec et al. (2010) conducted a study on 50 elderlies being trained with 12 weeks of 1-to-2 hours of Pilates-based exercises each. They found a significant improvement in the trainees' muscular flexibility and endurance at the end of the week 12 while the improvement in their body balance and posture was not significant [21].

In general, there has not yet been any standard treatment and rehabilitation method for LBP patients; Thus, therapist act on the basis of their personal experiences or sometimes trial and errors in their therapeutic procedures. These heterogeneous results are indicative of the inadequacy of information in this area of research accentuating the necessity of further studies. The specific attributes of Pilates method can help the achievement of improved posture and motor control in non-specific chronic LBP patients during exercise therapy. Therefore, Pilates can be considered as a proposed therapeutic approach to rehabilitation of non-specific chronic LBP patients [15-17]. Consequently, the present study intended to compare the effect of modified Pilates exercises and general exercises on lumbopelvic motor control, muscular endurance of multifidus and abdominis, back pain and functional disability in non-specific chronic LBP women.

Materials and Methods

The present study was a randomized clinical trial under the ethical code IR.ZAUMS.REC.1396.85. Once the letter of consent signed, the eligible patients participated in the study. Accordingly, they were randomly assigned to two groups of Pilates interventions (15 trainees) and general interventions (15 trainees). During the therapeutic program, each group received eighteen 50-min sessions of three-times-a-week treatment for 6 weeks in Razmjoo Moghaddam Clinic of Zahedan University of Medical Sciences. The research variables were measured and recorded before and after the interventions.

Research Population

The research population consisted of 30 non-specific chronic LBP women who were selected based on convenient sampling method. The inclusion and exclusion criteria have been elaborated bellow.

Inclusion Criteria

The inclusion criteria entailed any chronic LBP between the 12th rib and the rump region, irritation and stiffness in lumbar spine region with/without referral to the lower limbs (without root cause), a 3-month or prolonged course of the disease, age range of 18-50 years [4, 22] as well as no history of vertebral fracture, pregnancy, tumor, infection, previous spinal surgery, serious spinal deformities, cardiovascular disorders, vestibular system disorders, central nervous system disorders, visual impairment, neurological symptoms with sensory defects and motor paralysis included, and neurologic and rheumatic diseases [4, 10, 22].

Exclusion Criteria

The exclusion criteria involved the potential risk of exercises for patients, unaccomplished exercise therapy, exacerbation of symptoms, receiving further therapies along with exercise therapy and patients' absence in the trainings for more than three consecutive sessions [21].

Measurement Tools

The measurement tools included a demographic questionnaire for recording the participants' general information including age and so on, a tape measure with centimeter precision for measuring the subject's height, a digital scale for measuring the patients' weight and a pressure biofeedback unit for testing lumbopelvic motor control [23-25].

Treatment Method

Both groups received electrotherapy and exercise therapy as the main parts of treatment method. Electrotherapy followed the same procedure for both treatment groups before starting the exercise therapy:

- Applying Conventional Transcutaneous Electrical Nerve Stimulation (TENS) - at 80 Hz frequency and 120 ms diversion - for 20 minutes.
- Applying Ultra Sound (US) -at 1 MHz frequency and 1.5 w/cm intensity - on paraspinal muscles of lumbar region for 5 minutes.
- Using a Hot Pack on the lumbar region for 20 minutes.

The exercise therapy, however, followed a different procedure for both treatment groups i.e. one group received Pilates exercises while the other received general exercises. The patients were randomly assigned to each group. The training program schedule has been listed in Tables (2) and (3).

Sample Size

The sample size consisted of 15 subjects with reference to similar studies and the clinical trial nature of the present study. Subsequently, 30 patients with non-specific chronic LBP were selected to participate in the present study with regard to intended inclusion and exclusion criteria [21, 26-28].

Data Analysis

Once collected, data were analyzed in $SPSS_{17}$ software. The normal distribution of data was examined by Kolmogorov-Smirnov Normality test. The equality of variances was assessed using Levene's test. In case of abnormally distributed data, Wilcoxon Signed-Rank statistical test was used to compare the observed results before and after the intervention in each single treatment group (intragroup) while Mann-Whitney test was used to compare the observed results before and after the intervention between both groups (intergroup). The probability value (α) was considered as <%5 for statistical comparisons.

Results

The patients' demographic information including age, height, weight, BMI and so forth. has been presented in Table (1). The pre-recorded demographics of both groups were compared before the onset of intervention implying no significant difference between both groups in terms of the intended variables (Table 1). With regard to a pilot study, the sample size of the current study was estimated to be 30 subjects for both groups (each 15 patients). Finally, 30 eligible patients participated in the study. Table (4) has displayed the mean scores, P-values and results of pre- and post-intervention comparisons of such research variables as pain severity, functional disability, lumbopelvic motor control, muscular endurance of multifidus and abdominis of both treatments groups in solitary and in combination.

Intragroup Comparison

The results of intragroup comparison showed that there was a significant difference between the mean values of pain severity, functional disability, lumbopelvic motor control and muscular endurance of multifidus and abdominis in both Pilates-exercise group and general-exercise group before and after intervention based on Wilcoxon Signed-Rank test ($P=0.001$) (Table 4).

Intergroup Comparison

To ensure the accuracy of randomization process, the pre-intervention data were compared in both groups. The results demonstrated that there was not any significant difference between both groups in terms of the intended variables. That is, the mean values of pain severity, functional disability, lumbopelvic motor control and muscular endurance of multifidus and abdominis were normalized in the patients of both treatment groups. The results of intergroup (Pilates exercise versus general exercise) comparison displayed that there was not any significant difference between the values of lumbopelvic motor control, trunk muscular endurance and functional disability in post-intervention based on Mann-Whitney test ($P<0.05$) (Table 4).

Discussion

The purpose of the present study was to compare the effect of modified Pilates exercises and general exercises on lumbopelvic motor control, muscular endurance of multifidus and abdominis, back pain and functional disability in non-specific chronic LBP women. According to the present findings and results of research hypotheses testing, there was a significant improvement in the trunk muscular endurance, pain severity, functional disability in each group of patients in the course of intragroup post-intervention. In other words, both treatment groups witnessed positive outcomes in the intended variables. However, the results of intergroup comparisons showed that there was not any significant difference between the values of lumbopelvic motor control, trunk muscular endurance and functional disability of patients in both groups. In general, the results of the present study were representative of the positive effects of modified Pilates exercises on the treatment of non-specific chronic LBP patients.

Trunk Muscular Endurance

Reduced trunk muscle strength affects the spinal ability to react to the sudden and unexpected forces. It is also apparent that motor control is disrupted following the tiredness of these muscles after their exposure to recurrent forces, which becomes a risk factor for the onset or incidence of back pain [3, 6, 22].

As indicated by the results of the present study, the Pilates-exercise group experienced more significant changes than the general-exercise group. In Kliziene's (2016) study, the maximum isometric power of patients' trunk muscles increased after sixteen weeks and remained for almost two months [29]. Moreover, trunk flexor muscle endurance was significantly dependent on the trunk extensor muscle endurance. Kliziene believes that regular exercises can increase the strength of trunk muscles. On the other hand, the intensity of muscular contraction is lower in modified Pilates exercises as in stability exercises, the repetition of which rises trunk muscle endurance [20, 23, 30]. Therefore, the increased level of trunk muscle endurance in Pilates group can be attributed to this feature. The present study treated the subjects with an average 40 reps of each exercise per session for 18 workout sessions. Mostagi (2015) did not find any significant difference between the level of trunk muscle endurance in Pilates and general groups, which was consistent with the finding of the present study [27]. Moreover, there was not any intragroup difference in the level of muscular endurance as reported by the aforesaid study in contrast to the results of the present study. It seems that the variations in the sample size, type of exercises, number of repetitions, pain severity and fear may contribute to the difference in the results of Sorensen test. The mean age of female participants was 34.43 in the present study while it was

36.1 for both male and female subjects in Mostagi's study. Sex ratio is effective in Sorensen test results. Physiological and pathophysiological differences as well as the amount of pain and fear in patients are likely to affect the test results [31]. The type and repetition of exercises in Mostagi's study were not similar to the present study. The former included Mat and Apparatus Pilates exercises while the latter focused on the core exercises and trunk stability.

Lumbopelvic Motor Control

According to the results of the present study, the lumbopelvic motor control remained unchanged in the Pilates-exercise and general-exercise groups. In other words, modified Pilates exercised did not exhibit any positive effect on lumbopelvic motor control. Richardson and Hodges assert that transverse abdominis muscle (TVA) is the core component in spinal stability and the first active muscle in routine activities [9]. This muscle has an important role in lumbopelvic motor control. The role and activity of TVA muscle is assessed by measuring lumbopelvic motor control. Phrompaet showed that the 8-week Pilates exercises significantly improved lumbopelvic motor control and spinal muscle flexibility [26]. Pilates exercises focus on trunk muscles and breathing control that ultimately facilitate the activity of muscles involved in lumbopelvic stability. Furthermore, central nervous system plays a crucial role in the lumbopelvic stability which activates such stabilizers as transvers abdominis muscles against internal and external forces. CNS control over trunk stability is improved by challenging trunk control through external and internal forces (movement of body organs or use of exercise springs) in Pilates exercises. Gladwell et al. (2006) found that the 6-week Pilates exercises resulted in increased muscular flexibility, proprioception, enhanced general health and pain relief in LBP patients [19]. The proposed proprioception in Gladwell's study highlights the significant changes in spinal motor control [19]. The intended exercises used in the present study emphasized physical, mental and core elements that can significantly affect lumbopelvic motor control by particularly strengthening and controlling paraspinal, gluteal and abdominal muscles [32]. Based on the findings of the present study, neither modified Pilates nor general exercises had any significant effect on LBP. The insignificance of results may be due to the fact that the participants of the present study did not experience much defects in lumbopelvic motor control. Therefore, the proposed exercises could not lead to any apparent changes.

Pain and Functional Disability

Two important theories, namely vicious cycle theory and new pain adaptation theory, may advocate the clinical reasoning behind the observed mechanical effects of the exercises [33, 34]. On the one hand, vicious cycle theory proposes that the ischemic spasm in lumbopelvic muscles are induced by vascular compromise [33]; such ischemic spasm may lead to pain accumulation in the tissues of lumbopelvic region [35]. The pain may increase the irritability of gamma motor neurons, muscle tension or spasm. It can also impede further movements in the lumbopelvic region causing pain-spasm-pain cycle. On the other hand, pain adaptation theory suggests that pain decreases the contractility of lumbopelvic muscles that will ultimately results in their inefficient function [35]. Such inefficiency may be a snapshot of several lumbopelvic dysfunctions including inability to activate agonist muscles, time lag in the feed forward mechanism and decreased maximum output of agonist muscles [33], which may ultimately result in lumbopelvic dysfunction and poor lumbopelvic control [35]. Thus, enhanced tissue blood flow in lumbopelvic muscles may mitigate back pain and improve lumbopelvic motor control. Exercising can affect the proposed theories and eventually lead to one's pain relief and improved functional ability [35].

The results of the present study indicated that there was a significant difference in the pain severity and functional disability of both Pilates-exercise and general-exercise groups. That is, modified Pilates exercises presented a significant effect on the pain relief and improved functional ability of non-specific chronic LBP patients.

The findings of Antonino (2016) regarding the significant enhancement in functional ability of both Pilates and control groups were in line with the results of the present study [32]. The results of intergroup comparisons exhibited an improved mean score of pain in the Pilates group. According to Antonino, appropriate intensity and repetition of Pilates exercises resulted in more positive effects than that of general exercises. The proposed Pilates exercises used in Antonino's study did mentally and physically focus on core muscle regions through controlling strengthening abdominal, paraspinal and gluteal muscles. Thus, the significant pain reduction in Pilates group was allied to one's improved body balance and posture [32].

Furthermore, improvements in trunk muscle endurance and lumbopelvic motor control can lead to better movements, lower unsought forces, more appropriate muscular activity and better neuromuscular control that will ultimately result in one's pain reduction and return to routine performances.

Conclusion

In general, the results of the present study were indicative of the positive effects of modified Pilates exercises on increasing trunk muscles endurance, pain relief and functional disability improvement. Consequently, Pilates is recommended as a therapeutic program for the treatment of patients with non-specific chronic low back pain.

Table 1: Demographics of Intended Subjects

Intervention	Pilates	General	P-value
Age	**34.6±46.43	35.5±00.86	*0.81
BMI	25.3±09.86	26.4±52.34	0.34

*Values are significant at P<0.05; **Mean±SD of data

Table 2: Pilates Exercise Program

Weeks 1 & 2	Fundamental level: breathing, pelvic tilt, ABprep, flight, bridge (1 set, 10 reps)

Weeks 3 & 4	Fundamental level (2 sets, 10 reps) Leg kick side (1 set, 10 reps) Hundred with Swiss ball (1 set, 10 reps)
Weeks 5 & 6	Fundamental level (3 sets, 10 reps) Leg kick side (2 sets, 10 reps) Hundred with Swiss ball (2 sets, 10 reps) Swimming (1 set, 10 reps) Quadruped (1 set, 10 reps)

Table 3: General Exercise Program

Weeks 1 & 2	Stationary bike (10 min) Trunk muscles stretch (30s) Bipedal bridge (1 set, 10 reps)
Weeks 3 & 4	Stationary bike (10 min) Trunk muscles stretch (30s) Bipedal bridge (2 sets, 10 reps) Curl up (1 set, 10 rep)
Weeks 5 & 6	Stationary bike (10 min) Trunk muscles stretch (30s) Bipedal bridge (3 sets, 10 reps) Curl up (2 sets, 10 rep) Diagonal curl up (1 set, 10 reps)

Table 4: Mean Scores, P-values and Results of pre- and Post-Intervention Comparisons of the Intended Variables in both treatment groups

	Pilates-Exercise Group (N=15)			**General-Exercise Group (N=15)**			**Results of Intergroup Pre-intervention Comparisons**	**Results of Intergroup Post-intervention Comparisons**
Variable	**Pre-intervention**	**Post-Intervention**	**P-value**	**Pre-intervention**	**Post-Intervention**	**P-value**	**P-value**	**P-value**
Pain	**5.1±80.14	2.1±53.40	*0.001	5.1±40.68	3.1±73.43	*0.001	0.59	0.023
Disability	27.11±73.10	13.10±86.83	*0.001	23.11±53.60	15.10±73.30	*0.001	0.25	0.96
*****BKFO**	39.1±53.92	40.1±80.20	0.004	39.1±26.27	40.0±06.59	0.018	0.43	0.98
******KLAT**	40.1±86.76	41.10±46.51	0.20	41.1±46.45	41.0±46.63	0.78	0.18	0.90
Muscular Endurance of Multifidus	22.9±13.19	30.12±66.48	0.001	29.14±13.73	31.15±80.68	0.001	0.25	0.93
Muscular Endurance of Abdominis	22.18±60.94	38.25±20.53	0.001	24.13±33.46	27.13±33.64	0.001	0.32	0.13

*Values are significant at P<0.05; **Mean±SD of data; ***BKFO: Bent Knee Fall Out; ****KLAT: Knee Lift Abdominal Test.

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