EUROPEAN ACADEMIC RESEARCH
Vol. VII, Issue 7/ October 2019

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Effects of Pilate's training on lumbosacral muscles function, lumbar curve and pain

MEHRAN BEIGI MOHAMMADI
Research Scholar
Department of Studies in Physical Education and Sports Sciences
Sports Pavilion, University of Mysore, Mysore,India
C. VENKATESH, Ph.D
Assistant Professor
Department of Studies in Physical Education and Sports Sciences
Sports Pavilion, University of Mysore, Mysore, India

Abstract:

***Background**: The aim of this study was To evaluate the effects of 12 weeks of Pilate's exercises on lumbosacral muscles function and lumbar angle in Iranian females with Hyperlordosis.*

***Methods:** thirty Iranian female office workers aged between 35-40 with lumbar lordosis more than normal degrees (Hyperlordotic) that were randomly divided into exercise and control groups were selected as the study sample. The lumbar lordosis was measured using a flexible ruler, flexibility of hamstring muscles was measured with the active knee extension test, the hip flexor muscles strength was measured using Thomas test, the lumbar muscles flexibility measures by Schober test, abdominal muscles strength measured by Sit-Up test and back pain was measured using McGill's Visual Analogue Scales (VAS) questionnaire. Data were compared before and post-test using independent and paired t-testes.*

***Results:** Results showed that 12 weeks of Pilate's exercise led to significant decreases in lumbar angle and low back pain, increases in flexibility of hamstring muscles, hip flexor muscles flexibility, lumbar extensor muscles flexibility and abdominal muscles strength.*

***Conclusion**: The findings show that Pilate's corrective training can be considered as a useful and valid method for restoring*

and refining back deformities like as accentuated back-arc and became wreaked muscles' performance in lumbar areas.

Keywords: Pilates Exercises, Low Back Pain, Lumbar angle, hyperlordosis

INTRODUCTION

According to the literatures, the prevalence of back pain appeared to be higher among girls than boys [1]. One of the most common causes of back pain is spinal curve change in the waist. Lumbar lordosis is one of the most important parts of spinal pillar that has a special importance due to the unique position and having a direct contact with the pelvis. It should be paid special attention to the spine in order to have good physical condition [2]. In addition to the bones, ligaments, muscles and disks vertebra have also key role in lordos formation. Without muscles action, pelvic girdle performance hasn't sufficient stability [3]. Youdas (1996) found no relationship between the level of pelvic inclination and the degree of lumbar lordosis in a standing position [4]. Central stabilize of the vertebral column is supported by special muscles such as multifidus, transverses abdomin and internal muscles in trunk. These muscles act late in patients suffered from hyperlordosis [5].

The muscles provide stability of vertebrae in a focal form [3]. Weakness in any of the muscles of the lumbar-pelvic belt can follow pelvic rotations and versions of back-arc by impairing muscular balance in this area [6] and thus person can be musculoskeletal disorders [7]. Biomechanical and clinical studies have shown that muscles can provide segmental stabilization by controllingmotion in the neutral zone, and the neutral zone can be regained to within physiological limits by effective muscle control [8]. Von Lackum in 1924 showed that an increase in lordotic angle proportionally increases the shearing strain or stress in the anterior direction and shifts the center of gravity anteriorly. This increased angle and stress is thought by some to be associated with poor posture and back pain, leading subsequently to a decrease in the lumbar lordotic angle. From the mechanical point of view, the accentuated lumbar lordosis is associated with an increased prevalence of low back pain [9,10]. There

are various factors affecting lumbar lordosis. Some studies have shown that the range of lumbar lordosis is affected by age and sex, movement in the center of mass such as pregnancy or obesity [11,12]. Exercise is accepted increasingly popular to correct and refine such deformities. Lumbo-pelvic stabilization may be achieved by exercise aiming at appropriate posture and enhanced muscle function [12–14]. Exercises which have been widely used to treat such disorders for the purpose of strengthening spinal stability, restoring vertebral height, preventing collapse of vertebral body and achieving remarkable pain relief is reported in up to 93% of patients [15,16]. Teddy and colleagues (1994) preferred increasing hamstring flexibility by isokinetic training as an effective method to improve performance in the hamstring muscle [17]. Some studies have suggest that individuals with low back pain should refrain from specific back exercises instead focus on nonspecific physical activities to reduce pain improve psychological health [18]. Chen et al. (2011) suggested that the systematic back muscle exercise should be recommended as one of the treatment guidelines for vertebroplasty patients at least six months to be beneficial; however, the favorable effects could be for last two years [15]. Today, there are disputable agreements on which exercise protocol are most effective. Pilates exercise, a way Suitable for mind-body awareness and control practice Postural gestures with neuromuscular calling Ballast (19 & 20). Many patients with Back pain can be caused by doing Pilates exercises Increased abdominal, multi-head, muscle strength Pelvic floor and diaphragm muscle reduce pain Lumbar and prevent disease return (46). Accordingly looks at A demonstration of the effectiveness of this training set (Pilates) Low cost, safe and

Non-invasive, this kind of practice exercises Use of a large group of patients with low back pain Specifically, and other sections of society as a whole Take it. Also because Pilates sports on Many countries are known, but in Iran Not so old, so do this research Perhaps it could be an effective step in introducing this Be a fledgling sport in the country. Hence, the purpose of The present study examined the impact of 6 weeks of Pilates exercise therapy That's a relatively new and unknown method in this It is the domain and focus of his physical-mental exercises Is based on the factors of pain and endurance of individuals With chronic low back pain caused by lumbar disc herniation Examines. So, the aim of the present study

was to study the Effects of 12 weeks Pilate's training on lumbosacral muscles function, lumbar curve and pain

MATERIALS AND METHODS

Subjects

This is a pre-experimental design which was done at pre and post-test phases. All 35-40 years old female Office workers of Khoramabad city in Lorestan province, Iran, were selected as the study population. At first, all participants were called to participate in the study. Afterward, they were assessed for spinal and lumbar deformities by using New York test and checked board. Then, 30 subjects who were identified with increased lumbar lordosis and lumbar curveted more than normal rate, using a flexible ruler, were selected as the study sample. Subjects were randomly assigned into exercise group (n = 15) and control group (n =15). The age range of subjects was 35-40 years. The selected subjects had no training program during the past two months or physical therapy and they hadn't any history of spinal surgery. Subjects that seemed structural abnormalities also were excluded. During the training program if exercise led to exacerbate the symptoms of subjects were excluded. The subjects eligible for entry into the study fill consent form after written parental consent to participate in training to. All stages of consultation and study conducted under the supervision of a physiotherapist. The study was approved by the Ethical Committee of Physical Education Department of Lorestan province and Shaheed Shahram Pasand Hospital of Khoramabad.

Measurement tools

The angle of lumbar lordosis was measured with a flexible ruler via Youdas (1996) method [4]. The subject remained in the normal standing posture while lordatic angle was measured. The flexible curve was pressed against the spinous processes of the lumbosacral spine, and the points that intersected the adhesive markers were recorded. The points that intersected L1 and S2 were marked, and a line was drawn between them. These two measurements were used to calculate Theta (θ), an index of lordosis, using the following formula:
Hamstring muscle flexibility was assessed with the active knee extension test. Subjects were placed in a supine position with the

anterior thigh touching the crossbar of a testing apparatus. The hip and knee angles were visually estimated at 90". In this position, an inclinometer was placed 1 inch below and parallel to the fibular head. During the warm-up procedure, the subjects actively extended a leg four times while maintaining anterior thigh contact against the crossbar. Then, subjects actively extended the knee two additional times during which knee extension was recorded [17].

The test we used for abdominal muscle function was described by Kendall and McCreary (1983) [21]. In this test, a subject's score is the angle that the long axis of the legs forms with the horizontal plane during straight leg lowering. Subjects start in a supine position with the legs at a 90-degree angle to the table and end with the legs positioned horizontally (i.e., at 0 degrees with the table). The angle that is measured is that formed by the legs and the horizontal plane of the table when the subject no longer can keep the low back and pelvis firmly against the table. To control for the speed of the movement, we modified the Kendall and McCreary protocol. Our subjects were instructed to keep time with a metronome so that the action of leg lowering took 10 seconds to complete. The modified Schober method was applied for assessing spinal motion (lumbar extensors flexibility) [22]. The reliability of this technique was proved [23]. In this procedure, subjects used a pen to mark the midpoint between the posterior superior iliac spines (PSIS). Then use the tape measure to identify and mark two points: (1) one that is 10 cm superior to the PSIS, and (2) one that is 5 cm inferior to the PSIS. As the subject flexed the spine as far as possible, the distance between the superior and inferior marks was measured and recorded. Similarly, the distance between the superior and inferior marks was measured and recorded as partner extends the spine as far as possible. Thomas test was applied to identify shortage of hamstring muscles [24]. The subjects lie (supine) on table. Bottom just perched on end (easiest to start with both legs bent up against chest) and pull one leg against chest (with both hands) but keep her lower back in neutral, i.e. the pelvis mustn't roll up. Then the subject relaxes the other leg and lets it hang down, without changing in the lower back posture. (Be aware of neural tension, i.e. tingles, numbness or pins and needles, and do not force into this tension). The pelvis should stays square on bench, may need manual assistance In this study, for measuring the degree of pain (low back pain) we used Visual Analogue Scales (VAS) which

is one of the most common and also most sensitive methods of pain measurement. Therefore, a 10 cm line was drawn at the end of the questionnaire and the subjects were instructed to consider the beginning of the line as painless point and its end as the point for the most intense pain they have ever experienced since it started, and draw a short vertical line on this horizontal line to show it. The gap they specified was measured with millimeter ruler and recorded in the same questionnaire. Validity of this system in researches has been reported to be excellent [25].

Pilate's training protocol

1. *Pelvic tilt:* Lie on your back with knees bent, feet flat on floor. Flatten the small of your back against the floor, without pushing down with the legs. Hold for 5 to 10 seconds. 2. *Single Knee to chest:* Lie on your back with knees bent and feet flat on the floor. Slowly pull your right knee toward your shoulder and hold 5 to 10 seconds. Lower the knee and repeat with the other knee. 3. *Double knee to chest:* Begin as in the previous exercise. After pulling right knee to chest, pull left knee to chest and hold both knees for 5 to 10 seconds. Slowly lower one leg at a time. 4. *Partial sit-up:* Do the pelvic tilt (exercise 1) and, while holding this position, slowly curl your head and shoulders off the floor. Hold briefly. Return slowly to the starting position. 5. *Hamstring stretch:* Start in long sitting with toes directed toward the ceiling and knees fully extended. Slowly lower the trunk forward over the legs, keeping knees extended, arms outstretched over the legs, and eyes focus ahead. Table 1 6. *Hip Flexor stretch:* Place one foot in front of the other with the left (front) knee flexed and the right (back) knee held rigidly straight. Flex forward through the trunk until the left knee contacts the axillary fold (arm pit region). Repeat with right leg forward and left leg back. 7. *Squat:* Stand with both feet parallel, about shoulder's width apart. Attempting to maintain the trunk as perpendicular as possible to the floor, eyes focused ahead, and feet flat on the floor, the subject slowly lowers his body by flexing his knees. Each group performed special trainings for 12 weeks, 2 sessions per week; each session took about 1 hour. Duration of each exercise was 8 to 10 seconds in each set. Protocols were started with 1 set of 10 repetitions at starting baseline and by improving performance and patients' compatibility with trainings, all eventually finished with 3 sets of 20 repetitions at the end of protocols.

Statistical analysis

To determine the normal distribution of variables Kolmograv-Smirnov test (KS) was used. Paired t-test was used to assess the effects of exercise on lumbar lordosis in control and exercise groups and independent t-test was used for comparing differences between posttest of two groups. Values of p <0.05 were considered significant. Statistical analyses were performed using the 16 release version of SPSS for Windows.

Table 1. Comparison of the mean of lumbar curvature angle of experimental group to the control group in pretest and posttest (independent T test)

Time	Mean difference	T value	df	P value
Pretest	0.09	0.03	22	0.97
Posttest	11.09	5.16	22	0.001

Table 2. Comparison of mean of core stability of experimental to control group in pretest and posttest (independent T test)

Time	Mean difference	T value	df	P value
Pretest	0.04	0.004	22	0.997
Posttest	395.92	7.74	22	0.001

Table 3. Comparison of mean of pain of experimental to control group in pretest and posttest (independent T test)

Time	Mean difference	T value	df	P value
Pretest	0.09	0.005	22	0.997
Posttest	2.92	2.13	22	0.001

RESULTS

According to the pared t-test results, control group showed no significant differences in lumbar angle, flexibility of hamstring muscles, hip flexor muscles flexibility, lumbar extensor muscles flexibility, abdominal muscles strength and back pain after 12 weeks of corrective training (α = 0.05, p > 0.05) (Table 1). Results of the pared t-test in exercise group showed significant differences in lumbar angle, flexibility of hamstring muscles, hip flexor muscles flexibility, lumbar extensor muscles flexibility, abdominal muscles strength and back pain after 8 weeks of corrective training (α = 0.05, p < 0.05)

(Table 2). The results of independent t-test, in regard to compare two groups after 12 weeks exercise, showed significant differences lumbar angle, flexibility of hamstring muscles, hip flexor muscles flexibility, lumbar extensor muscles flexibility, abdominal muscles strength and back pain between control and exercise group afte 12 weeks of corrective training ($\alpha = 0.05$, $p < 0.05$)

DISCUSSION

The present study aims at studding the effects of Pilate's corrective training on lumbar arch and flexibility of tight and lumbar muscles in35-40 years old females suffered from hyperlordosis. The results of this study showed that 12 weeks of Pilate's back flexion exercises decrease lumbar angle, LBP and improves lumbar and hip muscles flexibility. These findings confirm previous statements [8,26–28]. There are many clinical studies suggest that lumbar lordosis, pelvic tilt, and abdominal muscle function are related to each other [20,29,30]. Many of these indications believe that this prediction is valid for subjects in a relaxed standing posture [21,31]. During normal standing, the degree of pelvic tilt is related to the depth of lumbar lordosis and that both are related to abdominal muscle function. So, any improvement in muscles function can lead to more suitable postural conditions [31]. This is alignment with our findings that indicate improvement of muscles function after administration the exercise protocol. It seems that the main causes of back deformities are weak trunk muscles strength and flexibility. Such a hypothesis is raised for the first time by Kendall and colleagues (2005). According to the statements, the goals that are obtained from exercise training can be attributed with improvement in lumbar muscles performance [21]. Rehabilitative experts commonly prescribe therapeutic exercise to correct these postural and movement faults. The exercises of William, increase strength, static and dynamic stability of the pelvic girdle, more perfectly flexible and people with chronic low back pain and improve function of the center immediately after the treatment [28]. Hamstring muscles stretching exercises seem to be commonly used and applied [32]. Based on the related studies, the main supportive muscles of the spine are flexor and improvement of back flexion strengthening with flexion exercises are suggested as the effective method to refine patients with spinal deformities [31–33]. Shields

(1997) showed the abdominal activity during sit-up movement and stated that in order to rehabilitation programs in LBP patients, strength training should be prescribed [34]. Abdominal muscles control pelvis tilt, support trunk and increase muscles strength in trunk [31]. Other studies claims that improvement in capillary circulation, relief the mild spasms in deep thin fibers and releasing relaxing hormone can be attribute to the positive effects of training on LBP [35]. This supports our data about decreased pain in lumbar via performing corrective training. Despite these claims, it was reported that lumbar lordosis, pelvic tilt, and abdominal muscle function during normal standing are not related [36]. For example, Toppenberg and Bullock (1986) examined the interrelationships of spinal curves, pelvic tilt, and muscle lengths in asymptomatic female subjects. Although they found longer abdominal muscles and shorter erector spinae muscles were associated with an increased lumbar curve however no relationship was found between pelvic tilt and lumbar curvature [37]. Such statements are rejected by current findings which demonstrate relations between these variables. Based on the some findings, exercises to stretch low back muscles don't have the mechanical advantage to improve lumbar lordosis [38,39]. No significant difference was found between normal subject and those with low back pain concerning the degree of lumbar lordosis [40]. Legaye and Beapere (2005) found a strong correlation between pelvic tilt angle and thoracic lordosis [29]. Although, it was reported that lower back stiffness may not the cause of LBP and only be a symptom of it [41]. Also, in the case of subjects who fall away from normal lordosis angles, there is a possibility that various types of pain could be caused during exercise [42,43]; however, while the overall lumbar flexing and extending torques showed similar tendencies during verification comparisons, quantitative difference existed between the experiment and calculated results [18]. The mechanism of pain decreasing via training is an increase of lumbar segments stability. This training emphasizes on retention of the exact simultaneous contraction pattern of deep muscles of trunk and transverse muscle of abdomen and multifidus [27]. The nervous adaption occurs at first during increased use of muscle or doing exercise which improves coordination, nervous tension, increase the efficiency of mobilization of motor neurons and activation of the neural correlates [27,44] and

elevates muscle performance level compared to pre-exercise levels [45].

CONCLUSIONS

There are various factors affect back deformities such as postural or mechanical disturbances, mobility characteristics and natural postural, hamstring muscles flexibility, lumbar lordosis, pelvic tilt, abdominal muscle function, sex and age. Decrease in the function of these variables can lead to spinal disorders. Back flexing or stretching exercises can reduce such stresses in pain relief in some back pain patients undergoing. According to the pervious and current results, Pilate's proponents have accepted as the effective protocol reduces recurrences of back pain. Our results suggest that 12 weeks of Pilate's back flexion exercises enhance the function of extended lumbar angle, flexibility of hamstring muscles, hip flexor muscles flexibility, lumbar extensor muscles flexibility and abdominal muscles strength and back pain. However, more research on this topic needs to be undertaken for achieving clear statements. For example, it is suggested to compare this program with other common protocols such as McKenzie protocol, Core stabilization training and Pilates on the mentioned factors. Also, with referring to our findings that support the benefits of Pilate's intervention on lordosis, the effects of this program on kyphosis can be investigated in future studies.

REFERENCES

[1] Amiri M, Mohseni-Bandpei MA, Mohsenifar H, Pourahmadi MR. Work related neck pain in Iranian dentists: An epidemiological study. Journal of Back and Musculoskeletal Rehabilitation, 2013;26(1):9-15.

[2] Kendall FP, McCreary EK, Provance P. Muscles, Testing and Function: With Posture and Pain. 5th ed. Baltimore, Md: Williams & Wilkins. 2005.

[3] Hodges PW, Moseley GL. Pain and motor control of the lumbopelvic region: effect and possible mechanisms. J Electromyography and Kinesiol. 2003;13: 361-370.

[4] Youdas JW, Garrett TR, Harmsen S, et al. Lumbar lordosis and pelvic inclination of asymptomatic adults. Phys Ther. 1996;76:1066-1081.
[5] Wagner H, Liebetrau A, Schinowski D, Wulf T , de Lussanet MHE. Spinal lordosis optimizes the requirements for a stable erect posture. Theor Biol Med Model. 2012;9:13.
[6] Norris, CM. Text Book of Back Stability. Human Kinetics; 2 edition (April 3, 2008).
[7] Bouchard S, Tetreault M. The Motor development of blind people. J Visual Impairment & Blindness. 2000;105:8-10.
[8] Danneels LA, Vanderstraeten GG, Cambier DC, Witvrouw EE, Bourgois J, Dankaerts W, De Cuyper HJ. Effects of three different training modalities on the cross sectional area of the lumbar multifidus muscle in patients with chronic low back pain. Br J Sports Med. 2001;35:186-191.
[9] VonLackum HL. The lumbosacral region. J Am Medical Associat. 1924;82: 1109.
[10] Fatma A, El-Hamalawy. A Newly Developed Exercise Program for Treatment of Mechanical Low Back Pain Associated with Accentuated Lumbar Lordosis. J Americ Sci. 2011; 7(8):58-70.
[11] Shirado O, Doi T, Akai M, et al. Multicenter randomized controlled trial to evaluate the effect of home-based exercise on patients with chronic low back pain: The Japan low back pain exercise therapy study. Spine. 2010;35:811-819. AUTHOR
[12] Lee SK, Jung JM, Lee SY. Gluteus medius muscle activation on stance phase according to various vertical load. Journal of Back and Musculoskeletal Rehabilitation. 2013;26(2):159- 161.
[13] Purepong N, Jitvimonrat A, Boonyong S, Thaveeratitham P, Pensri P. Effect of flexibility exercise on lumbar angle: A study among non-specific low back pain patients. Journal of Bodywork and Movement Therapies. 2012;16(2):236-243.
[14] Kofotolis N, Kellis E. Effects of two 4-week proprioceptive neuromuscular facilitation programs on muscle endurance, flexibility, and functional performance in women with chronic low back pain. Phys Ther. 2006;86:1001-1012.
[15] Chen BL, Zhong Y, Huang YL, Zeng LW, Li YQ, Yang XX, Jiang Q, Wang CH. Compression fracture patients: a randomized controlled trial Systematic back muscle exercise after percutaneous

vertebroplasty for spinal osteoporotic. Clinical Rehabilitation. 2011;26(6):483-492.
[16] Carvalho Barbosa A, Martins FLM, Almeida Barbosa MCS, Rubia ST. Manipulation and selective exercises decrease pelvic anteversion and low-back pain: A pilot study. Journal of Back and Musculoskeletal Rehabilitation. 2013;26(1):33- 36.
[17] Teddy W, Troy L, lason W. Effect of Hamstring Stretching on Hamstring Muscle Performance, JOSPT. 1994;20(3).
[18] Eric L, Hurwitz DC, Hal M, Chi Chiao MS. Effects of Recreational Physical Activity and Back Exercises on Low Back Pain and Psychological Distress: Findings From the UCLA Low Back Pain Study. Am J Public Health. 2005;95:1817- 1824.
[19] Anderson BD, Spector A. Introduction to Pilates – based rehabilitation. Ortho Phys ther clin North. 2000: 395-410.
[20] Searle S, Mecus C. Secrets of Pilates. Great British. 2001
[21] Kendall FP, McCreary PP. Muscles, Testing and Function: With Posture and Pain. 5th ed. Baltimore, Md: Williams & Wilkins, 2005.
[22] Schober P. Lendenwirbelsäule and Kreuzschmerzen. Much Med Wochenschr. 1937;84: 336-339.
[23] Moll JMH, Wright V. Normal range of spinal mobility, An objective clinical study. Ann Rheum Dis. 1971;30(4):381-387.
[24] Dennis RJ, Finch CF, Elliott BC, Farhart PJ. The reliability of musculoskeletal screening tests used in cricket. Physical Therapy in Sport. 2008;9:25-33.
[25] Gerry S. Improvement of chronic back pain or failed back surgery with vitamin D repletion: a case series. J Am Board Fam Med. 2009;22:69-74.
[26] Garshasbi A, Faghih Zadeh S. The effect of exercise on the intensity of low back pain in pregnant women. International Journal of Gynecology and Obstetrics. 2005;88:271-275.
[27] Inani SB, Selkar SP. Effect of core stabilization exercises versus conventional exercises on pain and functional status in patients with non-specific low back pain: A randomized clinical trial. Journal of Back and Musculoskeletal Rehabilitation. 2013;26(1):37-43.
[28] Ponte DJ, Jensen GJ, Kent BE. A preliminary report on the use of the McKenzie protocol versus Williams's protocol in the treatment of low back pain. J Orthop Sports Phys Ther. 1984;6:130-9.

[29] Legaye J, Duval-Beaupere G. Sagittal plane alignment of the spine and gravity: a radiological and clinical evaluation. Acta Orthop Belg. 2005;71:213-220.
[30] Chou R. Low back pain (Chronic). BMJ Publishing Group, Clinical Evidence. 2010;10:1116.
[31] Walker ML, Rothstein JM, Finucane SD, Lamb RL. Relationships between Lumbar Lordosis, Pelvic Tilt, and Abdominal Muscle Performance. Phys Ther. 1987;67:512-516.
[32] Li Y, McClure PW, Pratt N. The effect of hamstring muscle stretching on standing posture and on lumbar and hip motions during forward bending. Phys Ther. 1996;76:836-849.
[33] Sinaki M, Mikkelson BA. Postmenopausal spinal osteoporosis: flexion vs extension exercise. Arch Phys Med Rehabil. 1984;65:593-96.
[34] Shields RK, Heiss DG. An electromyography comparison of abdominal muscle synergies during curl and double straight leg lowering exercises with control of the pelvic position. Spine. 1997; 22(16):1873-9.
[35] Prins MR, Wurff PV, Groen GJ. Chronic low back pain patients with accompanying leg pain: The relationship between pain extent and pain intensity, disability and health status. Journal of Back and Musculoskeletal Rehabilitation. 2013; 26(1);55-61.
[36] Sinaki M, Itoi E, Rogers JW. Correlation of back extensor strength with thoracic kyphosis and lumbar lordosis in estrogen-deficient women. Am J Phys Med Rehabil. 1996;14: 370-4.
[37] Toppenberg K, Bullock M. The interrelation of spinal curves, pelvic tilt and muscle length in the adolescent female. Aust J Physio. 1986;32:6-12.
[38] Davis E, Gibson T, Tester L. The value of exercises in the treatment of low back pain. Rheumatology and Rehabilitation. 1979;18:243-247.
[39] Dennis RJ, Finch CF, Elliott BC, Farhart PJ. The reliability of musculoskeletal screening tests used in cricket. Physical Therapy in Sport. 2008;9:25-33.
[40] Papadakis M, Papadokostakis G, Kampanis N, Sapkns G, Katonis P. The association of spinal osteoarthritis with lumbar lordosis. BMC Musculoskeletal Disord. 2010;11(1):11-17.
[41] Mellin G. Physical therapy for chronic low back pain: Correlations between spinal mobility and treatment outcome. Scand J Rehabil Med. 1985;17:163-166.

[42] Kell RT, Risi AD and Barden JM. The response of persons with chronic nonspecific low back pain to three different volumes of periodized musculoskeletal rehabilitation. J Strength Cond Res. 2010;25:1052-1064.
[43] Ghassan SS, Chakib MA, Nathalie TD, Massud JT, Cherine EZ, Mukbil HH. Effect of Age and Lordotic Angle on the Level of Lumbar Disc Herniation. Advances in Orthopedics. 2011;1-6.
[44] Costa LOP, Maher CG, Latimer J, et al. Motor control exercise for chronic low back pain: a randomized placebo-controlled trial. Phys Ther. 2009;89:1275-1286.
[45] Alexandra P, Suzanne M, Angela M, et al. Clinical practice guidelines for the diagnosis and management of osteoporosis in Canada: Summary. CMAJ. 2010;182:1829-1873. A
[46] Akuthota V, Stilp S. Yoga and Pilates in the management of low back