

CHAPTER 6

DISCUSSION

The aim of this study was to compare four main outcome measures: lumbopelvic stability, flexibility, pain, and stress between Pilates and control groups. All main outcome measures except stress were improved in Pilates group only. Pilates training program consisted of continuous exercise that promote deep trunk muscle functions, improve strength, flexibility and lumbopelvic stability. Six concepts of Pilates were emphasized throughout the exercises period. All exercises promoted the stability of “powerhouse” which needs high concentration from deep trunk muscles control. The body and mind were controlled resulted in smooth and flow movement pattern. Moreover, focusing on breathing helped to improve breathing pattern and control the rhythm of movement during training. The effect of Pilates on each outcome measures was discussed below

6.1 Pilates effect on lumbopelvic stability

The hypothesis that Pilates training resulted in improvement of lumbopelvic stability was supported by this study. It was found that nineteen subjects from the Pilates group passed the lumbopelvic stability test but none from the control group. This result is in agreement with Herrington’s study, which tested in normal individuals (124).

Another study investigated the effect of four weeks exercise approach based on the Pilates method in unresolved chronic low back pain. No difference in mean isometric torque production from hip extensors within the entire study group was found (125). As the Pilates was an exercise that emphasized the core muscle, hence the lumbopelvic stability could be reestablished by this exercise program.

Lumbopelvic stability was an integration of three subsystems: passive, active and control. The active subsystem was created from functions of Transverse abdominis, lumbar multifidus, and pelvic floor muscles in order to control lumbopelvic stability. Voluntary contraction at low level of these muscles contributed to spinal stability (126).

The major principle of the Pilates method was the concept of centering. The exercise focused on deep abdominal muscles (13) that were used in stabilizing exercise (126). While performed the Pilates training, subjects had to consider the abdominal hollowing action in order to hold the trunk and pelvic for stability. Improvement of deep muscles function was benefit for reestablished feedforward control. Also the preset from Transverse abdominis activation was resulted from the body anticipated the load (127)

Regarding the lumbopelvic stability test, it can be categorized into screening test, clinical assessment and diagnostic assessment. Clinical assessment was used in current study followed Herrington's guidelines. This test is inexpensive, reliable, and easily applied, therefore it is suitable to use in clinical situation.

However, Clinical assessment of lumbopelvic stability test has some limitations. For example, the investigator must be a physiotherapist as high skill and knowledge are required for evaluation. During the test the investigator have to pay high attention on the pressure needle gauge, weight scale, and the compensations (128). Therefore, only one investigator may not be enough for lumbopelvic stability evaluation.

Instability of lumbopelvic region is associated with motor control. Motor learning may be used for management of this instability. Motor learning consisted of three stages, which were cognitive stage, associative stage, and autonomic stage. The appearance of high errors usually found in cognitive stage of learning, hence high conscious attention for organizing all element of movements are needed. At the beginning of Pilates training the participants must use a high level of awareness in order to train the specific isometric co-contraction. Transverse abdominis and lumbar multifidus have to be contracted at low levels of maximal voluntary contraction. Participants have to control respiration throughout the training program (129). Also verbal commands are used to guide and correct movement pattern. Moreover manual contacts are used for feedback to fulfill the Pilates training.

In the associative stage of motor learning, requirement of feedback is decrease. Increasing of correct and effective movement pattern appeared in Pilates participants. Hence the consideration of quality of movement was concerned to diminish verbal command and manual guide. The movement of all extremities in

natural way and more synchronize with breathing pattern reflected effective Pilates training.

The guideline for lumbopelvic stability training in low back pain was consisted of three stages. Array from easy to difficult, it is beginning with local segmental control, closed chain segmental control, and open chain segmental control. The training has to start from easy to difficult pattern. However, Pilates program used in this study did not follow this principles. All three stages of lumbopelvic stability training were combined in each session of Pilates training.

Pilates training program used in this study had two exercises that matched the local segmental control stage. They were Powerhouse control in standing, and Powerhouse control with relaxation. This helped to restore the kinaesthetic awareness and lumbopelvic position sense resulted in improvement in joint protection.

Closed chain segmental control used weight bearing on the limbs together with control of lumbopelvic movement. This study had four exercises related to closed chain segmental control, which were Spine stretch in squat, Spine curls, Hip rolls, and Kneeling with cat stretch. These exercises challenge the ability to control posture during the Pilates program.

Open chain segmental control challenged subjects to perform exercise while load is added throughout movement. Load of upper and lower extremities are utilized and subjects must control all movements during abdominal hollowing. Eighteen

exercises of current study correspond to open chain segmental control, which enhance functional movement tasks in a formal way. For this reasons the Pilates training subjects improved ability to control lumbopelvic stability after accomplished the exercise program.

Many evidences suggested a decrease of cross sectional area (62) and muscle fiber internal structure of multifidus (54-56) in chronic low back pain. Changes of this structure decrease lumbopelvic stability. While improvement in lumbopelvic stability after Pilates training was found, change in cross sectional area of multifidus is unknown. Because the composition of this muscle was not investigated in this study. Therefore, the improvement of lumbopelvic stability after Pilates training may be the result of functional improvement of multifidus, transversus abdominis, diaphragm, and pelvic floor muscle, which normally dysfunction in chronic low back pain (38, 48).

6.2 Pilates effect on flexibility

Pilates training was developed as a comprehensive method of stretching and strengthening exercise, which aimed to create strength and flexibility on mind and body (14). Regarding the Pilates training in this study, the flexibility of low back and hamstring muscle on Pilates group improved from 25.02 cm. to 30.65 cm. to 33.87 cm. at week 0, week 4, and week 8, respectively ($F_{(2,38)}=25.87, p<0.05$). For the control group no statistical change was found. The results generally supported the hypothesis that Pilates training had an effect on flexibility.

Limitation of trunk and pelvis range of motion in chronic low back pain is associated with tight hamstrings (66). As Pilates training was done with gentle and slow movement to the end range where a gentle stretching sensation was felt, this resulted in increased the trunk and hamstrings muscles flexibility. Jerky or quick movements were avoided and therefore, had less effect on the Ia and II spindle afferent fibers, which facilitated the stretch reflex via Golgi tendon organ (130). The stretch reflex was triggered by muscle spindle response and both velocity and duration of stretching forces applied to the muscle (74, 123). Furthermore, the bouncing or vigorous force had effected on the reflex contraction, which possible created microtrauma of muscle and lead to hypertonicity rather than relaxation of muscles (74).

Gentle and regular stretching affected length of muscle tissue and connective tissue. During stretch, sarcomeres which were the contractile unit of muscle tissue were lengthening. This resulted in increased of range of motion. Flexibility of muscle tissue also related to the connective tissue that supported individual and entire muscles. Two main types of connective tissue were collagen and elastin. Collagen provided structures and support, and elastin provided elastic and flexible. Gentle and regular stretching of the connective tissue caused lengthening of the wavelike elastin fibers. This change resulted in an increased of flexibility.

Stretching also affected sensory system that controls the muscle length. The level of sensory afferent from muscle spindles activated the muscle contraction response. The muscle spindle activity related to the muscle length. During the muscles

were stretched, muscle spindle activity had increased, but after released the tension these activity had reduced. Therefore, stretching a muscle and relaxing, and then stretching it again caused the muscle spindles to become slightly less sensitive. This enabled the muscle to stretch farther.

Sit and reach test was used in this study to evaluate trunk and hamstring flexibility. This test exhibited good reliability for assessing low back and hamstring flexibility in symptomatic and asymptomatic low back pain (72). The testing protocol was simple and easy to follow. As this test represented general flexibility of each individual, specific flexibility of each part of the body such as trunk or hamstring may be evaluated using other tests.

Regarding the principles of stretching, it comprised of four techniques, which were static stretching, ballistic stretching, PNF stretching, and active isolated stretching. Pilates movement pattern appear to be slow and smooth in nature. This pattern was similar to active isolated stretching. Therefore Pilates training was considered safe to perform in low back pain subjects. This technique did not exacerbate muscle and connective tissue hence activation of the stretch reflex was prevented (131).

The pattern of Pilates movements matched with active isolated stretching. Repetitive isotonic contraction as utilized in this training provided some benefits. It increased blood flow, oxygen and nutritional supply to tissue more efficiently than static or isometric contractions. In addition, focusing on respiration during exercise

decreased fatigue as a result of lactic acid reduction. Furthermore, safety and comfort were ensured because this technique was unlikely to produce any irritation during exercise (74).

The finding in this study demonstrated that the positive change of low back and hamstring muscle flexibility was due to Pilates training. The results were also supported by previous studies. Pilates training in healthy subjects for one hour session weekly for 8 weeks resulted in improvement of fingertip-to-floor test (18). This evidence confirmed that trunk and hamstring flexibility was increase by Pilates training.

Graves et al (81) investigated trunk and hamstring flexibility in chronic low back pain. Significant improvement was found after 12 weeks of Pilates training. However, an improvement of trunk and hamstring flexibility in the current study was found after only four weeks of Pilates training. Consider the Pilates training program, there were 11 exercises that influence an increase of trunk and hamstring muscle length. This included Spine stretch in finger-to-floor position that performed in warm-up and cool-down period, Hip rolls, Single knee folds, Single leg circle with knee flexion, Single leg circle with knee extension, Roll up in sitting position, Spine stretch in sitting with knee flexion, Spine stretch in long sitting, The saw, and Kneeling with cat stretch.

6.3 Pilates effect on pain

The results of this study support the hypothesis that Pilates training significantly reduced pain intensity from 4.69 to 2.15 and 1.05 in week 0, week 4, and week 8 respectively ($p < 0.05$). These findings may suggest that the Pilates training lead to reduction of pain intensity in chronic low back pain population.

Presence of Pain, lumbopelvic instability, and impairment in neuromotor control are consistently observed in low back pain patients (37, 132, 133). Numerous hypotheses have been developed to explain the improvement in pain. Possible theories that can be used to explain the effects of changed in motor control and trunk muscle function are pain-spasm-pain model and pain adaptation model (89).

Increased activity of the superficial trunk muscles in low back pain was reported in many studies and pain-spasm-pain model have been considered to debate this change (89). The traumatic structures that consistently found in low back pain were bone, ligament, end plate, annulus fibrosus, and deep trunk muscles. These structures generate nociceptive afferents via excitatory interneuron on the alpha motoneuron of superficial trunk muscles. Hyperactivity of these muscles was found, and also supported by previous investigations. Sustained activity of erector spinae muscle at end range of spinal flexion was established, which normally inactive at this range (113). Moreover, in low back pain patients erector spinae increased activity during heel contacts. This finding also presented in subjects who participated in experimental induced low back pain (87).

The model of pain-spasm-pain was correlated with pain that originated after injury. Treatment based on this model involved relaxation of injured structures and stretching of superficial trunk muscle (134). Current study demonstrated a reduction of average pain level in Pilates group. The improvement maybe due to the stretching effect from Pilates training. Stretching enhanced the increasing of superficial trunk muscle flexibility which induce to diminish the hyperactivity or spasm of this muscle.

Pain in chronic group including low back pain may be more complex than acute. Only the pain-spasm-pain model is not enough to explain change in pain level in Pilates trained subjects. Because Pilates training focused on contraction of deep trunk muscle, which required relaxation according to pain-spasm-pain model. Therefore, use of pain-adaptation model may provide more explanation of pain improvement.

The use of pain-adaptation model to explain the alteration of motor control in trunk muscle was reported under the condition of pain. Motor control serves to limit movement. During movement, decrease in agonist muscle activity and increase in antagonist muscle activity were demonstrated. These patterns of muscle activity limited the velocity, force, and range of motion (85).

The function of superficial trunk muscle generates torque at the trunk. The torque must be overcome by antagonist activation in order to keep the spine upright. This resulted in a compressive load on the spine (135). Excessive compression increased intradiscal pressure and loading through the posterior elements of the spine.

The compressive load has been considered to be a risk factor for spinal degeneration and pain (136).

The use of general exercise for low back pain management had a limited beneficial effect on pain or pain recurrence (137). Chronic low back pain often result in a general loss of function and de-conditioning as well as changes to the neural control system, affecting timing of patterns of co-contraction, balance, reflex and righting responses (138).

The stabilizing exercise approach was based on specific re-education of motor control and muscle function. This method has utilized for those muscles that contributed to stabilization of the lumbar spine (139, 140). O'Sullivan et al (44) used the principles of stabilization and neuromuscular control in their treatment protocol. The study found effective improvement in pain and functional disability in chronic low back pain individuals (44, 141).

Exercise program for low back pain including Pilates training provide some benefits for participants. Movements used in all exercises encouraged a reduction of stress and fear. The trained participants performed all exercises in Pilates program with confidence. Reduction of stress and fear promoted effective in re-education of motor control and muscle function. This change resulted in improvement of stability control. The appropriate recruitment of deep and superficial trunk muscles lead to pain reduction as well.

Pilates training aimed to strengthen the deep trunk muscles rather than superficial trunk muscles. Controlling of abdominal hollowing must be considered during multiple movement patterns. The Pilates training avoided facilitating an activation of the superficial muscles. The co-activation of these muscles increased load through the spine resulted in spinal injury.

In summary, reorganization of the control of the deep and superficial trunk muscles through motor learning strategies (142) leads to reduced pain and disability associated with low back pain (44) and recurrence of pain (143).

6.4 Pilates effect on psychological stress

Psychological stress of chronic low back pain subjects was evaluated using stress inventory questionnaire. This questionnaire consisted of 20 questions related to level of stress, physical changes from stress, and the feeling of self-esteem.

Although many evidences suggested that exercise help to decrease psychological stress, it was not supported by current study. The changes in scores of psychological stress in this study were not different when compared between Pilates and control group. However, the Pilates training group had significantly decrease in score of psychological stress from 2.53 in week 0 to 1.85 in week 4 and 1.63 in week 8 ($p < 0.05$). The trend in reduction of psychological stress score could propose that Pilates training was effective in stress management in chronic low back pain.

Exercises are always utilized in stress management. Different kinds of exercises including Pilates training were helpful as a therapeutic modality. Pilates training enhance improvement of psychological stress. The explanation of psychological effect from exercise is discussed below.

Pilates mat training was utilized in this study. Twenty four exercises were given to chronic low back pain participants. All selected exercises were unlikely to cause pain as they were suitable for beginner level. The 45 minutes of Pilates mat workout can be classified as lowmoderate intensity activity (i.e. 3.5 METS) (144). As mention, rhythmic exercise with 30-60% of maximum intensities for 30 minutes or more resulted in increase plasma levels of beta-endorphins. The increase in beta-endorphins was associated with mood elevation or anti-depressant effects. However, the intensity of Pilates training utilized in this study may be insufficient to affect the level of beta-endorphin release. Therefore, no difference of psychological stress between Pilates and control groups was found.

However, this study demonstrates that the Pilates group significantly improved psychological stress after participated in this study. The psychological stress changes after Pilates training may be explained as follow.

Evidences suggest that increasing of body temperature after exercise has indirect effect on CNS. This may improve cognitive function resulted in increase of oxygen and glucose transport to the brain. Demonstration of rising on body temperature resulted in increasing central and peripheral neuron activities, and also of

brain monoamines. Moreover the slow wave sleep was found after increasing of rectal temperature due to exercise enhanced sleeping quality.

This Pilates training program was suitable for low back pain. This program challenges their ability to perform this exercise effectively and the goal is not difficult to achieve. When subjects can control the performance in Pilates training as expected, a sense of achievement and mastery experience will occur. These changes may improve in self-esteem. Due to achievement to perform the exercise, the subjects were more confident to increase their activities in daily living and thus improve the sense of well being, which enhance to elevate psychological status. These changes were benefit for improvement in work capacity that also influences the subject to feel higher in work management.

The subjects in this study never attend the Pilates training class before. Therefore, this exercise may challenge their potential to perform all exercise in this program. All of subjects have to concentrate on their movements to perform effectively. Also the benefits of high cognitive on the exercise induce subjects to be distracted from their routine problems. In addition, the advantage of group exercise presented in this study may affect to increase relationship between subjects exercised in the same class. This can promote positive effect to psychological status.

6.5 Limitation of the study

The Pilates program used in this study mainly performed in forward direction. This may reduce the efficiency of Pilates training. The program must emphasized in

various directions such as forward, backward, and diagonal movement patterns. Exercises in different directions challenged the ability of muscular control and recruited its function.



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