Comparison between core stabilization exercise on sling and floor on pain, lumbar stability and postural sway in non-specific chronic low back pain: A pilot study

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Abstract

The purposes of this study were to compare pain, lumbar stability level and postural sway in anteroposterior (AP) and mediolateral (ML) between sling exercise and floor exercise in non-specific chronic low back pain (NCLBP). Twenty-six participants with NCLBP aged 20 to 50 years were divided into two groups; sling exercise (n=13), floor exercise (n=13). Both groups were received exercise 2 times/week for four weeks. The participants were performed 15 repetitions/set for three sets in each exercise. The modified isometric lumbar stability (MIST) was used to assess lumbar stability. The postural sway in the coronal and sagittal plane was evaluated by an accelerometer. Besides, the pain intensity at the lower back was measured by a visual analog scale (VAS). The repeated two-way ANOVA was used for statistical analysis. The results showed a significantly decreasing pain intensity and sway area in both groups after exercise ($p<0.05$). The reduction in VAS and sway area in AP and ML of the sling exercise group was significantly higher than the floor exercise group. The lumbar stability level was found a significant increase from baseline in both groups ($p<0.05$), but the sling exercise group provided more significant improvement of lumbar stability than the floor exercise group. Both groups indicated a significant reduction of pain intensity and sway area in AP and ML as well as improved lumbar stability level. The findings suggest that the sling exercise is a more significant reduction of pain intensity and sway area. Furthermore, the level of stability is more improved in the sling exercise.

Keywords: *chronic low back pain, core stabilization exercise, lumbar stability, postural sway*

1. Introduction

Low back pain (LBP) is an important problem that affects work, society, economics and quality of life (Andersson, 1999; Gheldof, Vinck, Vlaeyen, Hidding & Crombez, 2005). The prevalence of LBP illustrated that over 70% that occur back pain with a life-time of adult people (Rosario-MEDERI, do Maranhão, de Oncologia & Garcia, 2014). The epidemiology of LBP demonstrated that over 84% of the population had at least one episode of LBP in their lifetime (Nachemson & Andersson, 1982). Non-specific chronic low back pain (NCLBP) is most frequently found in LBP populations. NCLBP has developed into a major public health problem. The symptoms of NCLBP not be classified into a specific disease and not associated with the severe disease or serious back problems such as back pain from a slipped disc, malignancy, vertebral fracture, stenosis, spondylitis and severe spondylolisthesis (Childs et al., 2008; Chou et al., 2007). The area of pain is painful between the lower costal margin and not below the gluteal fold (Balagué, Mannion, Pellisé & Cedraschi, 2012). Common diagnoses for non-specific chronic LBP include an over-stretch of ligament or muscle, myofascial pain syndrome and muscle spasm. However, the cause may be related to minor problems associate with a disc, vertebrae joints as well as degenerative changes on the lumbar spine. Patients with back pain had many defects such as pain, poor function, and activities of daily living, moreover poor core muscle activities (Chou et al., 2007). The core muscle strengthening and stabilizer muscle recruitment were reported to decrease (Hodges, 2003). The patients with LBP were found a decrease in transversus abdominis contraction (Hodges & Richardson, 1996). Besides, the LBP patient had a slow stabilizer muscle contraction cause of problems in lumbar stability (França, Burke, Hanada & Marques, 2010). The previous study found that patients with low back pain had a lack of motor control and inadequate proprioceptive input. Also, LBP patients found loss of sensory input and anticipatory mechanism for preparing of movement (Shumway-Cook & Woollacott, 1995), which is a reason for increasing postural sway and poor trunk control.

The stability systems to be composed of an active system, passive system and neural system that co-working to control lumbopelvic and trunk. The stability is necessary to correct the movement of extremities, reduce force in the spine (Hodges, 2003; Panjabi, 1992). In LBP patient had injury of muscle and joint capsule resulting from poor active and passive subsystems, which is a cause of reducing lumbar stability and increasing the static and dynamic load on the spine (Panjabi, 1992).

Presently, the physical therapy treatment for improving back pain had many methods. Core stabilization exercise is an excellent, effective treatment. This exercise helps to activate core muscles, especially transversus abdominis and multifidus muscles. Sling exercise is the way that purpose to recovery functional and movement patterns as well as restores muscle coordination. This exercise challenges the neuromuscular control in patients with NCLBP. Besides, the sling exercise helps to promote the co-contraction of global and local muscles. The external perturbation from sling can promote the co-contraction of core stabilizers muscle than exercise on a stable surface. Exercise on the unstable surface stimulated the local stabilizer muscles, which were primary muscles for lumbar stabilization (Bal, 2012). The local muscle was found to support the spine and improve mobility that important to perform activities (Bergmark, 1989; Panjabi, 1992; Richardson, Jull & Hides, 2009). The local muscles are to decrease compression forces and reduce loads on the spine (Richardson, Hodges & Hides, 2004). Also, sling exercise provides the external perturbation which required greater neuromuscular control, such as feed-forward mechanism, proprioception and balance (Cairns, Foster & Wright, 2006; Marshall & Murphy, 2005). The patients with LBP had a reduction in proprioceptive and postural control bring to incorrect inputs to control trunk stability. The exercise on sling stimulated stretch reflex, which increased the postural control (Dietz, Mauritz & Dichgans, 1980). Kim et al. (2013) determined the effects of sling exercise on postural balance adjustment and muscular response patterns in patients with chronic low back pain (Kim, Kim, Bae & Kim, 2013). The results presented a significant decrease in pain intensity and functional disability. Besides, the study by Yoo and Lee (2012) who found sling exercise and floor exercise showed no significant differences in pain and muscle strengthening between groups (Yoo & Lee, 2012). The study from You, Su, Liaw, Wu, Chu & Guo (2015) investigated the effects of sling exercise on pain, disability, muscular strength and endurance. The results showed decreasing of pain and disability with significantly. Other than, the sling exercise can improving of strengthening and endurance of core stabilizer muscles (You et al., 2015). However, the evidence- based about sling exercise in NCLBP from previous study is a few. Moreover, lack of study about sling exercise in Thailand. And most importantly, no evidence base that assessed lumbar stability and postural stability after exercise with a sling, it is necessary to measure the main problems in NCLBP. Therefore, the present study was to the comparison of pain, lumbar stability level and postural sway in anteroposterior (AP) and mediolateral (ML) between sling exercise and floor exercise in non-specific chronic low back pain (NCLBP). The results from this study could be used for creating an effective exercise in patients with non-specific chronic LBP.

2. Objectives

This study aimed to investigate the effect of core stabilization exercise on sling and floor on pain, lumbar stability and postural sway in non-specific chronic low back pain.

3. Materials and Methods

3.1 Participants

Twenty-six participants with NCLBP were selected to participate in this study. Ethical approval was permitted by the Ethical Committee of Rangsit University, Thailand. This study is a randomized controlled study. This study used gender-matched by choosing a pair of women or men who are the same age and allocated the participants to the sling and floor group. The patients were randomized into either the exercise on sling (SG) or exercise on floor (FG) group by sealed envelope. The inclusion criteria consist of chronic low back pain or back pain for more than three months. All participants had NCLBP symptoms for more than twelve weeks that includes an area of pain between the costal margin and the gluteal fold (Balagué et al., 2012). The age range of participants was between 20-50 years old. The exclusion criteria comprised of radicular pain or back pain from serious diseases such as herniated disc nucleus pulposus (HNP), trauma, cancer and infectious diseases. Moreover, the patients with recently of back and abdomen surgery or spinal fractures were excluded from this study. Besides, back pain intensity of participants not to exceed 60 millimeters on a 100-millimeter visual analog scale (VAS). If the participants had previously performing core stabilization exercise or activity that related to core stability training such as Pilates exercise, were excluded. The participant was asked to sign the informed consent before participating in this study.

3.2 Procedures

Participants in both groups were trained transversus abdominis muscle contraction before the exercise program. The training assisted the participants to learn muscles contract with correctly. Moreover, the training assisted the participants to familiarize themselves with the pressure biofeedback unit. All participants received muscle contraction training for 10 minutes in the supine position. The training is abdominal breathing in a supine position for every participant to learning of transversus abdominis contraction and breathe correctly. Participants were asked to lie in supine with both knees bent and feet on the floor. When inhaled, the participants were asked to keep their chest stable with expanding the abdomen. When exhaled, the abdomen moved back toward the lumbar and continued with this for ten minutes (Richardson et al., 2009). The participants did not acknowledge whether which group provides better outcomes. The treatment program, outcome measures, and data analyses were evaluated by different researchers to eliminate the bias in the treatment.

Figure 1 Training of transversus abdominis muscle contraction

The demographic such as age, weight, height and gender were recorded before participating in the exercise. The pain intensity, level of stability and postural sway were assessed at pre-exercise, after exercise in week 2 and week 4. The back pain intensity was measured by VAS. The VAS is a straight line 0-100 mm. The VAS was used for measuring the pain intensity. The "0 mm" is no pain, and "100 mm" is the worst possible pain (Collins, Moore & McQuay, 1997; Mannion, Balagué, Pellisé & Cedraschi, 2007). The VAS was reported during movements of lumbar that showed mostly painful.

Both groups were received the exercise eight training sessions, two days per week for four weeks. Each time of exercise, the participants were performed 15 times/set for three sets with one minute resting between sets. The exercise will be done for four weeks. Before exercise, all participants were tested in the appropriate exercise position. Each participant was considered to the progression of the exercise position every week based on the correct performance of the previous position (Figure 2).

The starting position in the sling group is supine with arms beside the body. Both knees bent at 90 degrees placed on a narrow sling that was placed below the knees. The sling height is supporting in a knee bent at 90 degrees. The sling exercise consists of 3 levels with difficultly by decreasing of a base of support.

Level 1: both leg placed on the narrow sling, Level 2: only right leg placed on narrow sling and control pelvis in the same level, and Level 3: only right leg placed on narrow sling with arms on chest and control pelvis in the same level.

The starting position in the floor group is supine with arms beside the body. Both feet placed on the floor with knee bent at 90 degrees. The floor exercise consists of 3 levels by decreasing of a base of support. Level 1: both feet placed on the floor, Level 2: only right leg placed on floor and control pelvis at the same level, and Level 2: only right leg placed on the floor with arms on chest and control pelvis at the same level.

In both groups, the participant performed abdominal drawing while exhale with raising the pelvis and maintain the pelvic lift in a neutral position. The participant was maintained in this position for three breathing cycles. The participant was asked to draw an abdomen without moving of lumbar and pelvis.

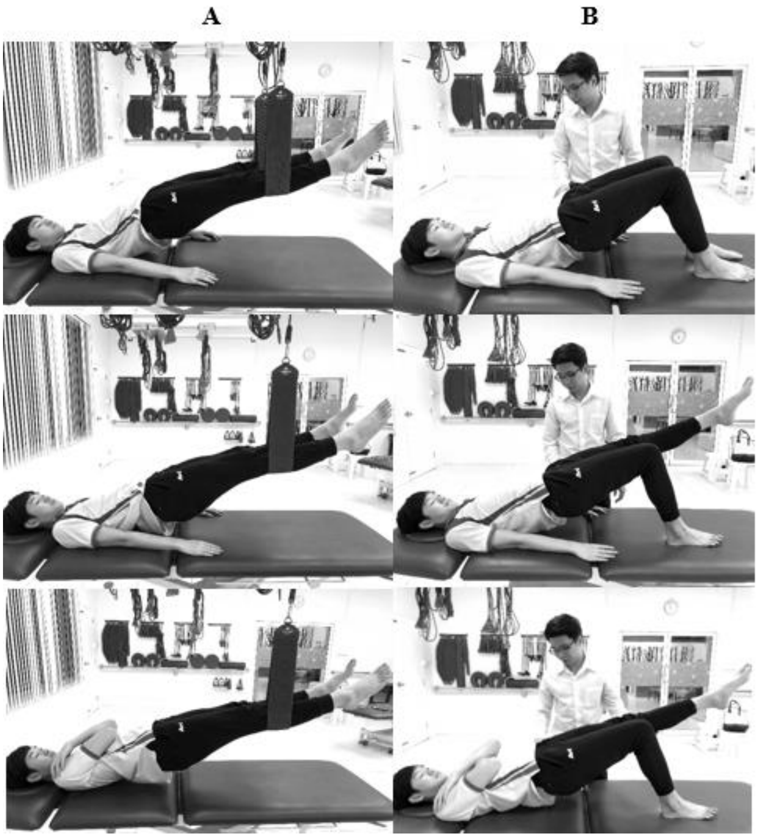

Figure 2 Exercise position; A = Sling group (SG), B = Floor group (FG)

3.3 Outcomes measurement

The lumbar stability was evaluated by a modified isometric stability test (MIST) (Hagins, Adler, Cash, Daugherty & Mitrani, 1999; Wohlfahrt, Jull & Richardson, 1993). The MIST consists of six levels, by which a higher level showed high lumbar stability. In each level, the participants were performed abdominal drawing without the sway of the trunk and pelvic. The pressure biofeedback unit (PBU) was laid down under the lower back. The researcher was squeezed the pressure to 40 mmHg for the beginning. For each level, the participant was asked to do the abdominal drawing and control the pressure at 40 ± 4 mmHg for three breathing cycles to show passing the level. The position in each level composed of level 1: abdominal contraction for three breathing cycle, level 2: abdominal contraction with open the right leg almost 45 degrees, level 3: abdominal contraction with straightening of the right knee, level 4: abdominal contraction with lift off the right leg from the floor until hip bent 90 degrees, level 5: abdominal contraction with lift off the right leg from the floor and then lifted off the left leg, and level 6: abdominal contraction with raising both legs until hip bent 90 degrees. This study was to determine intra-tester and the inter-tester reliability of the MIST measurement. The intraclass correlation coefficient showed excellent intra-tester and inter-tester reliability of all raters.

The postural stability was determined by the accelerometer. The volunteers wore the accelerometer sensor on the lower back. The participants were asked to sit on a chair without a backrest and feet lift off the floor. The balance foam was placed on the chair to disturb stability. The participants were attempted to sit in a stable as much as possible for two minutes. The postural sway was done for one time in each participant. The variable included sway area in the sagittal plane (anteroposterior; AP) and coronal plane (mediolateral; ML).

3.4 Statistical analysis

The SPSS version 24.0 was used for statistical analysis. The Kolmogorov- Smirnov Goodness-of-fit test was used to test the distribution of data. The two-way mixed ANOVA with posthoc pairwise and Bonferroni adjustment was used to determine the pain intensity, lumbar stability, and postural sway in the coronal and sagittal plane. The level of statistical significance was set at $p<0.05$.

3.5 Sample size calculation

The sample size was determined by G*power version 3. The standard level alpha = 0.05, 80% power, and effect size = 0.5 were used to calculate the sample size.

4. Results and Discussion

The demographic data and baseline characteristics of both groups are showed in Table 1. Each group consisted of six men and seven women. The data of age, weight, height and body mass index (BMI) were normal distribution. Also, both groups were not significantly different between groups. Moreover, the pain intensity, level of stability and sway area at baseline were presented not significantly different.

Table 1 Baseline characteristics of the participants

Characteristics	SG	FG	*p*-value
Age (years) Mean (SD)	33.14 (17.12)	39.70 (15.90)	0.534
Weight (kg) Mean (SD)	51.52 (5.31)	52.87 (6.40)	0.356
Height (cm) Mean (SD)	157.5 (6.64)	162.4 (7.75)	0.158
BMI (kg/m^2) Mean (SD)	20.87 (1.52)	22.23 (1.66)	0.451
Gender (male/female)	6/7	6/7	1.000
VAS (mm) Mean (SD)	54 (12)	48 (13)	0.763
MIST Median (Q1,Q3)	2 (2, 3)	2 (2, 3)	0.301
Sway area in coronal plane Mean (SD)	1.65(0.07)	1.54(0.14)	0.352
Sway area in sagittal plane Mean (SD)	1.77 (0.13)	1.58 (0.08)	0.413

SG = Sling group, FG = Floor group

The analysis of time and intervention interaction effects on the pain, lumbar stability and postural stability was a significant time effect ($p < 0.001$). All outcome measures in both groups showed significantly increased over time from baseline to week 4. There were significant improvements of VAS, MIST level at all-time points of the exercise.

Both groups represented a significant decrease in pain intensity through exercise intervention within-group ($p<.001$) and between-group ($p<.001$). As shown in Figure 3, the pain intensity at week 2 and week 4 between both groups significantly differed ($p<.001$). Moreover, both the SG and the FG showed significant differences in pain intensity between baseline and week 2, baseline and week 4, week 2 and week 4 ($p<.001$) (Figure 3). Analysis of variance test to compare the different outcomes within SG and FG was presented in Table 2. The results showed that there was a significant difference between core stabilization with sling and floor groups on pain intensity and lumbar stability at week 2 and week 4 after treatment. On the other hand, the results demonstrated no significant difference in the sway area at two weeks after treatment. However, both groups showed a significant difference in the sway area at week 4.

Table 2 Analysis of variance results of outcome parameters among the sling and floor groups, pre-intervention, end of 2nd week and 4th week (end of intervention)

	Sum of Squares	**Mean Square**	**F**	***p*-value**
Baseline				
VAS (mm)	21	16	1.75	0.763
MIST	2	2	1.43	0.301
Sway area in coronal plane	3.19	1.60	2.31	0.352
Sway area in sagittal plane	3.35	1.68	1.00	0.413
2nd week				
VAS (mm)	28	14	11.60	0.023
MIST	3	6	1.71	0.045
Sway area in coronal plane	0.073	0.064	0.404	0.533
Sway area in sagittal plane	0.191	0.134	3.667	0.072
4th week				
VAS (mm)	78	37	11.52	0.024
MIST	4	2	4.13	0.031
Sway area in coronal plane	0.306	0.215	0.376	0.044
Sway area in sagittal plane	0.300	0.226	9.178	0.007

* Significant difference at p< 0.05
VAS = Visual analog scale, MIST = Modified isometric stability test

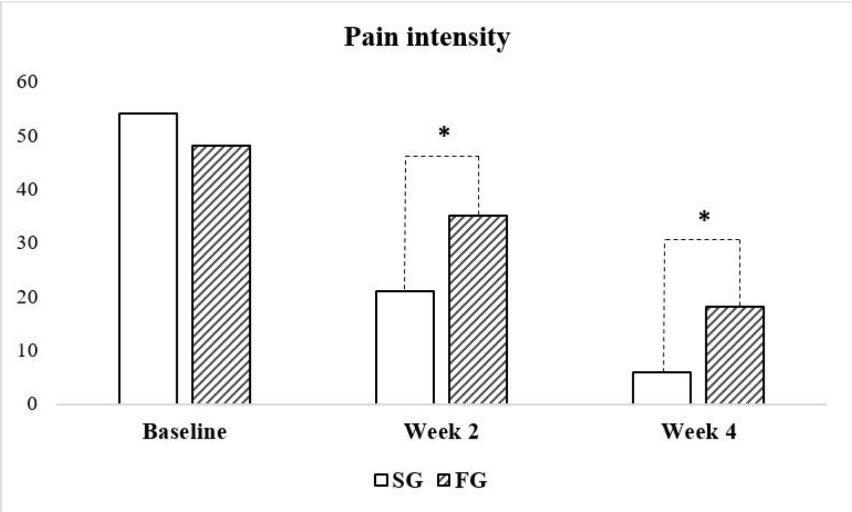

Figure 3 Mean VAS scores at baseline, week 2 and week 4 for Sling group (SG) and Floor group (FG)

The MIST scores demonstrated a significant difference between both groups at week 2 and week 4 (p<.001). However, the lumbar stability for the SG was significantly greater than those for the FG (p<.001). Besides, both groups showed significant improvement of MIST form baseline and week 2, week 2, and week 4 (p<.001) (Figure 4).

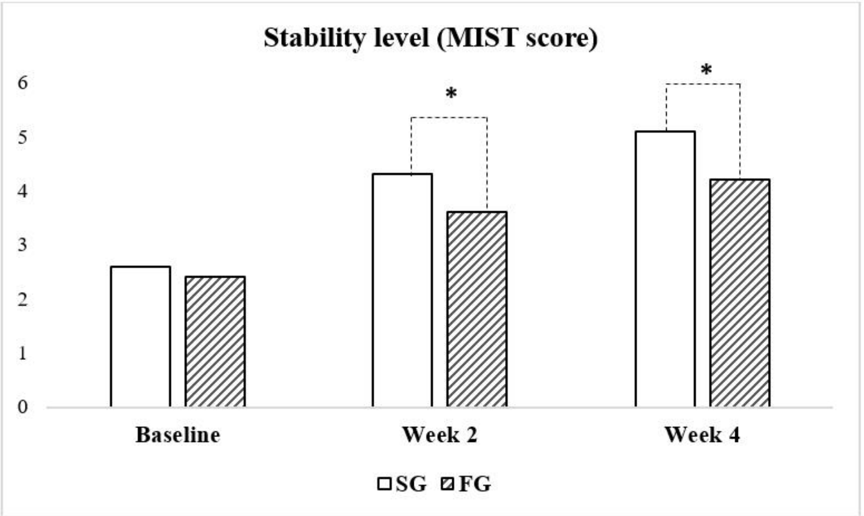

Figure 4 The MIST scores at baseline, week 2 and week 4 for Sling group (SG) and Floor group (FG)

The postural sway in both groups was indicated to decrease significantly from baseline. The results show that the sway area in the coronal and sagittal plane was a significant decrease at baseline and week 4 in both groups ($p<.001$). Also, when comparing the change in the postural sway (coronal and sagittal plane) between both groups, the results demonstrated no significant difference at week 2. However, the postural sway demonstrated a significant difference between both groups at week 4 ($p<.001$). The result showed the SG was higher decreasing of sway than the FG with significantly ($p<.001$) (Figure 5).

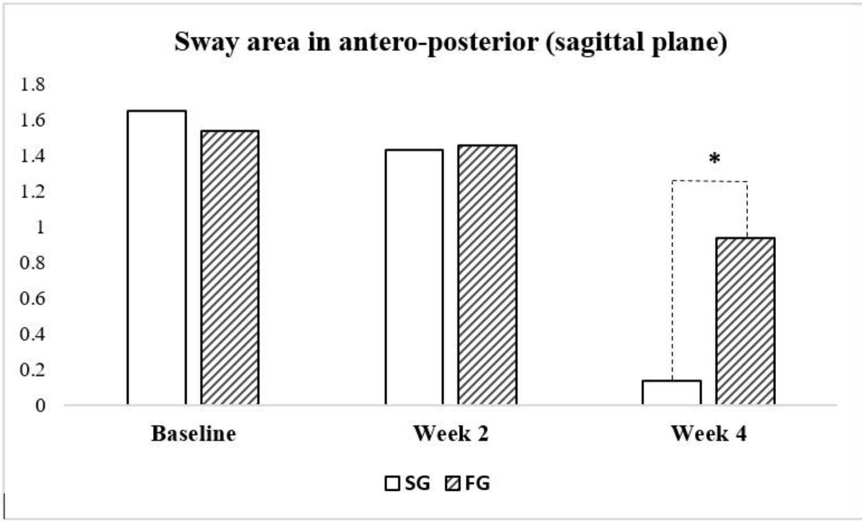

Figure 5 Mean root mean square (RMS) sway in antero-posterior (sagittal plane) at baseline, week 2 and week 4 for Sling group (SG) and Floor group (FG)

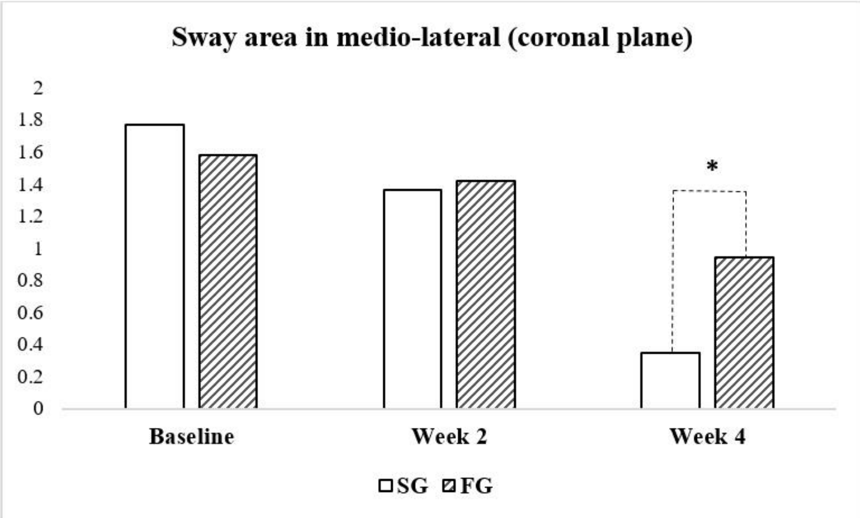

Figure 6 Mean root mean square (RMS) sway in mediolateral (coronal plane) at baseline, week 2 and week 4 for Sling group (SG) and Floor group (FG)

5. Discussion

The findings of this study showed a significant decrease in pain intensity and postural sway in anteroposterior, as well as mediolateral after exercise in both groups. Besides, the SG showed more reduction of pain and sway than the FG. Moreover, both groups were improved of lumbar stability level significantly. However, the SG had a trend to increasing of stability level than the FG. The SG group showed more effective than exercise on a floor could be caused by the exercise intensity level using the sling correct the optimal threshold resulting in higher tissue adaptation. When exercise on sling occurs appropriately challenge the neuromuscular control to improve the function of core muscle in the patients with NCLBP. This finding similar to a study from Kim et al. (Kim et al., 2013) that found sling exercise is effective in decreasing pain, improving postural balance and increasing function of muscle in LBP patients. In patients with low back pain had decreased proprioceptive input from joint and muscle that effect to motor control. Other than, low back pain (LBP) causes of loss of sensory information to control a strategy of postural adjustment (A Shumway-Cook & Woollacott, 1995). The patient with low back pain found delays postural response and reaction time that effect functional ability (Boucher, Teasdale, Courtemanche, Bard & Fleury, 1995). Moreover, patients with LBP had delayed contraction of transversus abdominis and multifidus, resulting in a lack of stability (França et al., 2010). This agrees with the previous study that explained about the problems of LBP are impairments of lumbar proprioception, impaired core muscle function causing poor postural control and pelvic stability (Radebold, Cholewicki, Panjabi & Patel, 2000). Sling exercise is an unstable exercise that aggravating of neuromuscular control. When exercising on a sling that stimulates proprioceptive brings to the recovery of deep trunk muscles as well as effective in normalizing muscle response (Carpes, Reinehr & Mota, 2008). If core muscle is optimal activities, the lumbar stability level is improving. In addition, exercise on unstable surface promotes muscle recruitment by the central nervous system (CNS) which increase stabilizer muscle activity and joint receptor to control the balance of trunk and lumbopelvic (Mutlu Cuğ, Özdemir, Korkusuz & Behm, 2012). Sling exercises focus on global and local core stabilizers which control feed-forward mechanisms before movement. When exercise on the sling is resulting in more recruitment of core stabilizer muscle than exercise on the floor (Kim et al., 2013; Yoo & Lee, 2012). Core stabilizer muscles helped minimize compression forces on the spine, decreasing stress on spinal structures that effect to reduce pain (Bergmark, 1989; Panjabi, 1992). The core stabilization exercise with sling encourages nerve root activity, proprioceptive sense and anticipatory postural adjustment that effective in decreasing of postural sway (Kirkesola, 2009). The result showed a significant difference between groups of the sway area at only 4 weeks. These results may describe that exercise did not sufficiently activate the postural stability in the short periods. Patients with NCLBP had impaired core muscle activation causing poor postural control (Panjabi, 1992; Radebold et al., 2000). The patients with NCLBP found a delay of transversus abdominis muscle contraction and loss of somatosensory information cause of decreasing feed-forward activation before movement (Bergmark, 1989; Costa et al., 2009). Motor learning is very important to activate core stabilizer muscles and re-education of function (Anne Shumway-Cook & Woollacott, 2007). Therefore, the duration of exercise may spend a period of training time to learn the core muscles contraction and to improve strength that helps to increase postural sway.

Limitations of this study are small sample sizes that cannot represent all of the patients with NCLBP. Moreover, the duration of treatment included short periods of exercise. Further research will investigate following up with long-term effects as well as longer periods of exercise to achieve the effect of motor learning. Besides, the electromyography (EMG) of core stabilizer muscles during exercise should also be measured to confirm the muscle contraction are correct.

This study tries to minimize selection bias. The participants are randomly assigned to the sling group or floor group who unknown about the results of treatment to eliminate the participants' bias. The outcomes assessed by a blinded examiner who had unknown the group of exercises. Also, the outcome measures and data analyses were evaluated by different researchers. The results from this study demonstrated that sling exercise more improved of pain intensity, lumbar and postural stability in the patients with NC LBP. When performing the exercise with a sling showed greater stabilizer muscle activities comparing with exercise on a stable surface. Therefore, the core stabilization exercise on a sling is more suitable for clinical in a rehabilitation program. The results of this study could be used for clinics to select more effective treatments in NCLBP.

6. Conclusion

The results indicated that both groups show improving lumbar stability and decreasing pain intensity as well as postural sway. Moreover, the results showed a significant difference in the lumbar stability levels, pain and the postural sway in both the coronal plane and the sagittal plane between SG and FG. The results demonstrated that there was a significant difference between core stabilization with sling and floor groups on pain intensity and lumbar stability at week 2 and week 4 after treatment. The postural stability at week 4 found a significant difference between groups, whereas the SG and FG demonstrated no significant difference between groups at week 2. Furthermore, the patients with NCLBP who received sling exercise had more significant improvement in lumbar and postural stability than exercise on the floor. Moreover, in sling exercise group show more reduction of pain intensity than floor exercise. Therefore, the core stabilization exercise with a sling is more effective for clinical practice to reducing pain and sway along with improving lumbar stability.

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