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EFFECT OF STATIC STRETCHING ON MUSCLE ACTIVATION DURING SIT TO STAND AMONG LOW BACK PAIN POPULATION

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Graphical abstract

Hamstring flexibility	Pre intervention Mean (SD)	Post intervention Mean (SD)	P value
Right	35.00 ± 8.66	26.82 ± 6.81	0.001
Left	37.27 ± 9.58	26.36 ± 8.09	0.001

Abstract

Differential muscle activation pattern following hamstring stretching among low back pain (LBP) is being reported. Reduce in hamstring extensibility can alter the lumbar lordosis during sitting thus put pressure on lumbar intervertebral discs and increase load on the lumbar spine. This can lead to changes in the pelvic motion and altered the functional movement especially during sit to stand (STS). Thus, the faulty motion and muscles will be used and further lead to the changes of muscle activation especially to the back and lower limb muscles. Previous study showed that static stretching can help to increase activation of muscle among LBP population. However, limited evidence exists regarding the effects of static hamstring stretching on muscle activation of gluteus maximus during STS among LBP population. The main objective is to determine the effect of static hamstring stretching on hamstring flexibility on muscle activation of gluteus maximus (GM) during STS among LBP population. Forty four subjects, 44 LBP populations were recruited based on the selected criteria as set by the study protocol. The results of the study showed, there were an improvement on hamstring flexibility and muscle activation when static stretching was applied to LBP population ($p<0.05$). This study suggested that static hamstring stretching exercise can help to improve the hamstring ability to lengthen and increase the activation of GM during STS especially for LBP population.

Keywords: Static Stretching, muscle activation, low back pain population

1.0 INTRODUCTION

Low back pain (LBP) is a common health problem that leads to the primary cause of disability and work loss [1]. Early symptoms usually appeared between the age of thirty and fifty [2]. Most of the patients usually experience low grade-LBP with limited disability. However, some patients predispose to chronic or disabling back pain [3]. The disability could lead to various biomechanical alterations such as changes in the lumbopelvic movement and reduce in the activation of back muscles. Out of many biomechanical alterations, altered movement patterns have been suggested as one of the possible causes for developing chronic, recurrent LBP [4].

Alterations in movement pattern could be due to multisegmental movement which would have an increased mobility component as well as demanded stability in the lumbar segments [1]. When the trunk mobility alters, the functional movement also will be disturbed. Prolonged mechanical stress or repetitive stress by flexion of the trunk deforms the viscoelastic tissues of the lower back and contributes to the back pain [5]. Shum *et al*. (2007) suggested that alteration of lumbar spine mechanics (L5-S1) and hip mobility gives an impact to the quality of life as lumbar spine and hip region works together in many functional activities especially sit to stand and forward bending movement. Inability of the hamstring to extend properly and stiffness of tissues surrounding lumbar region were the main factors of the alteration [1].

Previous study [6] states that alteration in the viscoelastic properties of tending to increase the risk of having a low back pain. Limitation in the hamstring extensibility may alter the lumbopelvic rhythm [7] and alters the lumbar lordosis during sitting position. In addition, this will eventually increase the lumbar intervertebral discs pressure and the load on the lumbar spine [8]. Finally, it will lead to changes in the pelvic motion and altered the functional movement, especially sits to stand and forward bending motion [1].

Higher level of GM activation pattern can be observed during erect standing and when the body performing trunk flexion movement [19]. This is because the main function of GM is to accelerate the body forward and upward, besides act as a hip stabilizer [14]. Delayed in GM activation usually occurred in order to reduce the worsening of LBP condition. However, a compensation of other muscles will occur to allow the body to perform the movement, thus create a faulty motion [14].

A study conducted by Newcomer *et al*. [19] not only focusing on GM muscles, but also erector spinae (ES) activation. Both ES and GM muscles are crucial muscles during STS movement. GM most active during the hip in flexion position from range 45° to 60° [14] meanwhile, ES is active when the body in 0° to 30° [18].

The purpose of this study was to determine whether the static stretching helps to improve muscle activation of GM during STS among LBP population. We hypothesized that patients with LBP will be having an alteration of GM during STS movement. Furthermore, we hypothesized that static stretching does help to improve the activation of GM among LBP patients.

2.0 MATERIALS AND METHODS

Forty nine LBP subjects were recruited for participation in this study (age 22 years ± 1.65 years, height 1.59m ± 0.08m, body mass index (BMI) 22.56kg/m^2 ± 4.53kg/m^2). All the subjects who showed willingness were requested to sign an informed consent that was approved by ethical board of University Technology MARA, Malaysia. Subjects were free from history of cardiovascular diseases, trauma, fracture or surgery in the pelvis or lower limbs and those with BMI more than 30 were excluded from the study.

As for the EMG reading, there were three data recorded which were muscle activation of GM, time taken for the muscle to become most activated and duration of the muscle to sustain the position. The baseline value for muscle activation of GM was $1.65 \times 10^{-3} \pm 6.80 \times 10^{-5}$, 2.5 secs and 4.7 secs for time taken for the muscle to become most activated and duration of muscle to sustain in STS position respectively.

LBP subjects were assigned into intervention group (static stretching) (n=44). Three subjects dropped out as they did not meet the inclusion criteria meanwhile two subjects were dropped as their condition exacerbate after intervention applied.

The flow of the study is as follow:

1. Selection criteria
2. MVC reading of GM by using EMG
3. Goniometer reading of hamstring flexibility
4. STS task
5. Exercises - static stretching
6. Post reading value

First procedure was started with the examiner cleaned the tested legs (right and left) for electromyograph (EMG) electrode placement on the gluteus maximus (GM). Electrodes were placed over the midsection of the muscle bellies. The placement for the electrode was 34% of the distance between the second sacral vertebra and the greater trochanter. EMG data were recorded using a DELSYS system (DELSYS Inc.) To evaluate gluteus maximus maximal voluntary contraction (MVC), subjects were positioned in prone lying with their hips extended 10°. They were instructed to gradually increase their force to maximum over 2 seconds, and then maintain a static hold for 5 seconds, and gradually decreased force to rest over 2 seconds. Prior to each task, subjects were allowed one attempted in order to make them familiar with the task. The same examiner applied manual resistance during the task. Each task involved 3 repetitions with one minute rest, and the maximum of the three was recorded for further analysis [9].

Next, all subjects were instructed to supine on the table with contralateral hip and thigh strapped down for stability and subject is placed into 90˚ knee flexion. A goniometer was utilized to measure the hamstring flexibility of both legs. For goniometer placement are; axis - lateral aspect of knee through the center of the joint line, stationary arm – parallel to the shaft of the femur and moving arm – along the shaft of the fibula in line with the lateral malleolus. Then the subject is asked to actively extend the knee until an initial stretch was felt in the hamstring. The knee angle is measured when the patient felt the initial resistance in the hamstring [10].

Following the procedures, both groups were instructed to perform STS movement to measure the GM activation during this functional task. A stool with neither armrest nor backrest was used because this type of stool support from ischial tuberosities to the middle of the thighs. The stool height used was 110% of knee-floor length, means that distance between the apex of the fibular head and the floor. This task was performed without the use of rebound. While performing STS movement, both of hands were folded over the chest. The initial posture was fixed in sitting position, with the knees and ankles flexed at 90°. The instructions were "On the 'go' signal cross your chest and stand up and still until I tell the trial is done." Subjects were instructed to cross their arms before standing because we want to eliminate in arm used among participations [11]. Then, they were instructed to rise freely at their comfortable speed and then maintain a comfortable, erect posture for 3 seconds.

They were then instructed to sit down on the chair at their comfortable speed. No correction on any deviations or body movements during the test. Each subjects repeated the movement for 3 times.

As all the procedures above being carried out, an intervention which was static stretching was prescribed to the subjects. Subjects in the stretching group were instructed to perform static hamstring stretching 3 times per week for 4 consecutive weeks [7]. Static hamstring stretching was done for a single 30 seconds. Prior to testing, pre and post reading of hamstring flexibility and muscle activation of GM during STS was measured for LBP subjects. On the last day intervention, all LBP subjects were again tested in the same fashion. Paired t-test was used to analyze pre and post reading of hamstring flexibility and muscle activation of GM during STS task.

3.0 RESULTS

The characteristics of the study subjects were as follows: LBP subjects (age 22 years ± 1.65 years, height 1.59m ± 0.08m, body mass index (BMI) 22.56kg/m^2 ± 4.53kg/m^2). Table 1 shows the physical characteristic of subjects

Table 1 Physical characteristic of subjects

Demographic characteristics	LBP subjects (n=44)
Age (year), Mean (± SD)	22.00 ±1.65
Height (m), Mean (± SD)	1.59 ± 0.08
BMI (kg/m^2), Mean (± SD)	22.56 ± 4.53

The comparison of post intervention also showed a significant difference ($p<0.05$) on hamstring flexibility (Table 2) and muscle activation of GM during STS among LBP subjects (Table 3).

Table 2 Hamstring flexibility pre and post intervention

Hamstring flexibility	Pre intervention Mean (SD)	Post intervention Mean (SD)	P value
Right	35.00 ± 8.66	26.82 ± 6.81	0.001
Left	37.27 ± 9.58	26.36 ± 8.09	0.001

Table 3 shows the significant difference of mean score of pre and post reading of activation after passive hamstring stretching was applied to LBP group

- 1st row showed the muscle activation of both right and left GMmuscles
- 2nd row showed the time taken for the muscle to become most activated
- 3rd row showed the duration of muscles to remain active

Variable	Muscles	Pre intervention	Post intervention	P value
Muscle activation	GM Right	$1.63 \times 10^{-3} \pm 2.76 \times 10^{-5}$	$1.69 \times 10^{-3} \pm 4.03 \times 10^{-5}$	0.008
	GM Left	$1.64 \times 10^{-3} \pm 2.91 \times 10^{-5}$	$1.69 \times 10^{-3} \pm 4.00 \times 10^{-5}$	0.010
Time of muscle most activated	GM Right	2.74± 0.16	2.09± 0.12	0.001
	GM Left	2.73± 0.13	2.12± 0.14	0.001
Duration of muscle activated	GM Right	3.62 ± 0.17	4.79 ± 0.15	0.001
	GM Left	3.66 ± 0.27	4.73 ± 0.18	0.001

4.0 DISCUSSION

This research has shown that patients with LBP problem had reduced their activation of GM during STS which signifies these subjects did not exhibit active movement of GM during STS task. When LBP subjects perform STS task the muscle unable to remain active for a long period of time due to muscle weakness. These results are in agreement with previous studies [12] who examine the muscle activation during STS movement among healthy young women who wearing different height of high-heeled shoes. An increase in the anterior pelvic tilting can lead to the stress to the lower lumbar region will occur as the load of the trunk was held by lower lumbar trunk which causes lower back injury to occur [12]. In addition, abnormal stress on the lower back can occur as the muscle not activated specifically for a particular movement thus create LBP condition.

Based on the results collected, it can be observed that most of LBP subjects used their trunk than pelvis to perform STS task. This showed that there is an alteration of lumbopelvic kinematic movement when performing STS. As the normal kinematic movement alters, the muscle recruited during performed STS also being altered. During performing STS, the movement of lumbar and hip is important to make sure that lumbopelvic rhythm works properly [7]. When a healthy person does sit to stand, the pelvis will moves first, then followed by lower lumbar region (L5-S1). However, when the LBP patients performing the same motion, the changes of lumbopelvic rhythm can be observed due to reduce in the ability of hamstring muscles to extend properly and weakness of gluteus and back muscles [1]. Reduce in back and gluteus muscles will change the normal movement of sit to stand due to reduce ability of muscles to sustain in one position for a long period of time. Thus, this eventually makes the muscle recruit in a different manner and altered the normal movement during sit to stand [1].

In contrast, previous study [12] revealed that no significant differences in the muscles activation between chronic LBP and healthy subjects when they standing in neutral position. This study focuses more on ES muscles compared to GM muscle. However, Ferguson (2004) [18] found a significant different on ES activation on both healthy and LBP subjects which healthy subjects demonstrated earlier and longer activation pattern of back muscles. The reasons behind this might be due to neuromuscular changes among LBP group. The findings suggest that ES activation increased from range 0 to 30 degree in both healthy and LBP group. This is because as the trunk flexion increased, the moment of trunk extension decreased, thus reduced the activation of back muscles. Thus, ES more active in standing position [18]

Furthermore, it can be observed that there was an alteration of muscle activation patterns of LBP patients. This might occur since the patients would recruit their muscle in a different manner [1]. Early activation of the spinal erector and hamstrings muscles and delayed muscle activation of gluteus maximus has been interpreted as an indication of faulty muscle activation [13]. Gluteus muscles should activate first, followed by hamstring and erector spinae muscles as the gluteus muscles are important to accelerate the body upward and forward from a hip flexion position ranging between 45° to 60° [14]. A sign of over activity of the hamstring muscle can be seen as a knee in excessive flexion [13]. In addition, if hamstring muscle is activated earlier that gluteal muscle it can cause hip dysfunction and anterior hip pain to occur because the pattern increase anterior joint forces [13].

A previous study on muscle activation during STS among stroke patients [15] [16] also supported our study and state that muscle activation of the affected limb is weaker compared to the unaffected limb of stroke patients. Muscles that have been examined in this study were tibialis anterior muscles, soleus and quadriceps muscles. These muscles were chosen in these studies because of their function in influencing anteroposterior stabilization of the knee and ankle joint among healthy subjects [12] [15]. However, these muscles play a role as postural response in hemiplegic patients [15]. They found that there was a significant difference of muscle activation of all muscles when compared between affected limb and unaffected limb. Therefore, muscle activation of GM may reduce in term of voltage of muscle activation.

Hamstring tightness is commonly observed among LBP subjects. The reason behind this might due to inability of hamstring muscle to, withstand the higher tension when the muscle is lengthened. This can further leads to alteration of muscle activation during STS because the muscle was recruited in a different manner due to compensation of lumbar spine and hip movement.

This finding is supported by previous literature [17] who found that reduced hamstring muscle's ability to lengthen can increase the risk of getting a lower back injury. Similarly, there was previous study [1] state that hamstrings tightness is commonly observed in patients with low back pain problems. When the length of hamstring muscles, reduces, it will increase the incidence of back pain up to 15% [7]. The injury might occur to the back as the hamstring muscle unable to withstand the higher tension when the muscle lengthens. Lack of hamstring ability to extend also is thought to induce changes in lumbopelvic rhythm [7].

Stretching exercise was suggested as one of the methods to prevent any decreasing in hamstring flexibility. It has not only helped in increasing muscle strength and flexibility, but also help to reduce the patient disability to manage their activities daily living. This is because increased in the ability of the muscles to lengthen may change the lumbopelvic rhythm during sit to stand. Thus, the correct muscles can work properly without recruit other muscle to do the movement and at the same time reduce the disability to manage daily activities and improved the quality of life.

5.0 CONCLUSION

Our finding revealed a significant difference in pre and post static stretching on hamstring flexibility and muscle activation of GM during STS among LBP population. The study will create awareness among therapies and patients themselves in understanding the importance of maintaining hamstring flexibility thus help therapists to prescribe the effective treatment to the patients. It is also important for the patients to strengthen GM muscle as reduce GM strength can alter the kinematic lumbopelvic movement, thus help to reduce the incidence of getting back pain.

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