LEE KAH YI EFFECTS OF DIFFERENT GLUTEAL STRENGTHENING PROGRAMS 2022

# EFFECTS OF DIFFERENT GLUTEAL STRENGTHENING PROGRAMS ON STRENGTH, PAIN, FUNCTIONAL DISABILITY AND BALANCE AMONG UNIVERSITY STUDENTS WIITH NON-SPECIFIC CHRONIC LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL

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By

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A Research project submitted to the Department of Physiotherapy,
M. Kandiah Faculty of Medicine and Health Sciences,
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in partial fulfillment of the requirements for the degree of Bachelor of Physiotherapy (Honours)

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# EFFECTS OF DIFFERENT GLUTEAL STRENGTHENING PROGRAMS ON STRENGTH, PAIN, FUNCTIONAL DISABILITY AND BALANCE AMONG UNIVERSITY STUDENTS WIITH NON-SPECIFIC CHRONIC LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL

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## ABSTRACT

**Background and Objective:** Non-specific low back pain (LBP) has become a common health issue encountered by university students nowadays. Gluteal strengthening program was being prescribed for the management of LBP due to the association of glutes and spine. However, there is lack of study conclude that which gluteal strengthening program is more effective to treat LBP among university student. Therefore, the aim of this study was to determine whether the novel gluteal strengthening program (NGSP) has more effects on strength, pain, functional disability and balance compared to the standard gluteal strengthening program (SGSP) among university students with non-specific chronic LBP.

**Methods:** A randomized controlled trial was conducted for 4 weeks and 40 subjects with chronic non-specific LBP are recruited through simple random sampling. Participants were randomly assigned into control group (n=20) and intervention group (n=20). Trunk and gluteal muscle strength, functional disability, pain, and balance was measured at baseline and following 4 weeks of interventions. Trunk and gluteal muscle strength were measured using a hand-held dynamometer, pain intensity assessed by Visual Analogue Scale (VAS), functional disability measured by Oswestry Disability Index (ODI) and the balance was assessed by Y-balance test. The data collected were then analyzed using Paired-samples t-test and independent-samples t-test in IBM SPSS software statistics version 20.

**Results:** A total of 40 participants were recruited but only 36 of them (male = 14, female = 22) with the mean age of 20.94 ± 1.76 completed the study. For strength, pain, functional disability, and balance, there were significant differences between pre- and post-test ($p < 0.05$). However, there was no difference in all variables measured between both groups ($p > 0.05$). No sex difference was reported for all variables.

**Conclusion:** NGSP and SGSP are equally effective in improving trunk and gluteal muscle strength, pain, functional disability and balance but NGSP is recommended because it is time-effective, contains a lesser number of exercise and no equipment is required for the exercise when compared to SGSP.

**Keywords:** Low Back Pain, gluteal strengthening program, university students

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**APPROVAL SHEET**

This Research project entitled "**EFFECTS OF DIFFERENT GLUTEAL STRENGTHENING PROGRAMS ON STRENGTH, PAIN, FUNCTIONAL DISABILITY AND BALANCE AMONG UNIVERSITY STUDENTS WIITH NON-SPECIFIC CHRONIC LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL"** was prepared by LEE KAH YI and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (Honours) at Universiti Tunku Abdul Rahman.

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## PERMISSION SHEET

It is hereby certified that **LEE KAH YI** (ID No: **19UMB04198**) has completed this Research project entitled "EFFCTS OF DIFFERENT GLUTEAL STRENGTHENING PROGRAMS ON STRENGTH, PAIN, FUNCTIONAL DISABILITY AND BALANCE AMONG UNIVERSITY STUDENTS WIITH NON-SPECIFIC CHRONIC LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL under the supervision of MR MUHAMMAD NOH ZULFIKRI BIN MOHD JAMALI (Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health sciences.

Yours truly,

________________

(LEE KAH YI)

## DECLARATION

I hereby declare that the Research project is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Signature:

Name: LEE KAH YI

Date:

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| ICC | Intraclass correlation coefficient |
| LBP | Low Back Pain |
| M | Mean |
| NGSP | Novel gluteal strengthening program |
| ODI | Oswestry Disability Index |
| P | P value (Significance) |
| SD | Standard Deviation |
| SGSP | Standard gluteal strengthening program |
| UTAR | Universiti Tunku Abdul Rahman |
| VAS | Visual Analogue Scale |

# CHAPTER 1

# INTRODUCTION

## 1.1 Chapter overview

This chapter outlines the background of study and provides the context for the entire research project. The study's importance and relevance was discussed, followed by the research objectives, hypotheses and operational definition of the terms used in this study.

## 1.2 Background of study

Low back pain (LBP) is the sensation of pain arising from the lumbar region which is the back area below the ribcage. The lumbar spine is a crucial structure where the bones, muscles, joints, ligaments and nerves combine to give structural support to the spine. However, the lumbar spine is prone to injury and pain because it bears the weight of the upper body and allows trunk movement (Roig, 2020). Hussein et al. (2009) categorized LBP into specific and non-specific types. Specific LBP occurs due to a known pathology such as a tumour, lumbar spine fracture and structural deformity while the non-specific LBP refers to pain that is difficult to localize and does not have a specific pathology. According to the National Institute of Neurological Disorders and Stroke (NINDS, 2020), LBP is classified into an acute type which is less than 12 weeks and a chronic type which lasts longer than 12 weeks. Individuals who experience LBP may also have other associated symptoms such as muscle tightness or spasms in the low back area and glutes.

Gluteal muscles have an essential role in maintaining musculoskeletal health. Lee and Kim (2015) stated that the hip joint function is linked to the low back because the location of the hip joint is close to the lumbopelvic region and they perform a single action. Frizziero et al. (2021) claimed that the deficiency of gluteus maximus and gluteus medius strength would cause LBP because gluteal muscles regulate the forces from the lower limb to the spine. Thus, any deficits in these muscles exert pressure on the sacroiliac joint and cause the functional failure of the low back. Besides that, Kendall et al. (2015) stated that there is a weakness in the gluteal extensor and gluteal abductor muscle strength due to improper posture caused by LBP. This finding is supported by a study conducted by Lee and Kim (2015) who found that patients with LBP tend to develop a round back posture with hip, knee and ankle joint flexion which create tension in the hip joint.

Furthermore, patients with LBP frequently reported that they have physical discomfort and face difficulty in functional activities. Thus, their social engagement and physical activity level have been reduced (Pereira et al., 2017). For example, psychological stress such as anxiety and depression are the common emotional symptoms in LBP patients. The constant discomfort feeling that they experience in the low back region also affects their daily living activities, especially university students' academic performance (Casas et al., 2016, as cited in Anggiat et al., 2018).

Stability of the sacroiliac joint is essential as the activation of muscles such as multifidus, transversus abdominis, internal oblique and gluteus maximus directly results in the lumbar spine and pelvis stability (Hungerford et al., 2003, as cited in Kim & Yim, 2020). Multifidus and transversus abdominis muscles maintain body balance in all movements because they contract more quickly than the other muscles involved in the lumbar segmental stabilization (Hodges & Gandevia, 2000, as cited in Jeong et al., 2015). Hence, patients with LBP usually have a slower response than the normal healthy individual when a sudden load is applied to the body due to weak muscles that cannot maintain balance. According to Hicks (2018, as cited in Kim & Yim, 2020), elderly patients with chronic LBP always complain of pain in the hip joint and morning stiffness. Patients who undergo total hip replacement surgery also found that their low back and gluteal pain intensity has been reduced (Fukuda et al., 2021).

Physiotherapy role is vital in LBP management. Various interventions can be used to treat LBP such as the manual therapy, spinal manipulation and exercise program. Several lines of evidence suggested that core stability exercise is more effective than other exercises due to the activation of core muscles such as transversus abdominis and multifidus (Frizziero et al., 2021). McGill stabilization exercise is an effective core stability program to improve LBP and functional disability so it was selected as the standard treatment for both control and intervention groups. Evidence suggests that the anteroposterior muscles will become stiffer and more well-coordinated with each other after practising the McGill stabilization exercise thus reducing pain and improving the function of the lumbar spine during functional tasks (Ghorbanpour et al., 2018). Additionally, a study conducted by Burns et. al. (2018) found that LBP patients who receive intervention that targets the hip and lumbar spine experience a greater decrease in pain and perceived disability over time in comparison to patients who receive treatment targeting the lumbar spine alone.

The most effective exercise program to strengthen gluteal muscles for the LBP population has yet to be established. The standard gluteal strengthening program (SGSP) for the control group is selected from a study conducted by Fukuda et al. (2021) because it was applied in several studies and proven to be effective in treating LBP (Fukuda et al., 2021), sacroiliac dysfunction (Added et al., 2018), patellofemoral pain (Lack et al., 2015) and acetabular labrum tears (Yazbek et al., 2011). The gluteus maximus is a strong gluteal extensor while gluteus medius is a strong gluteal abductor. Both of these muscles contribute to the stability of the pelvis and lower extremities thus strengthening these two muscles may reduce LBP. The exercise that activates the gluteus maximus the most is forward step-up while side-bridge to neutral spine position activates gluteus medius the most (Reiman et al., 2012). However, the effectiveness of these exercises needs to be studied in the non-specific chronic LBP population. Thus, a novel gluteal strengthening program (NGSP) comprised of these two exercises was given to the intervention group to study their effectiveness in treating LBP.

Studies have been conducted to compare the effectiveness of gluteal strengthening program but the extent to which specific gluteal strengthening exercise produces the best outcome for LBP remain controversial. The research on this topic presents conflicting findings as some studies showed that gluteal strengthening exercise does not have a significant improvement in pain and functional disability compared to conventional trunk exercises (Fukuda et al., 2021; Kendall et al., 2015). Previous studies have almost focused on the pain and functional disability outcome of LBP while this study assessed additional components such as trunk and gluteal muscle strength and balance performance before and after the intervention. Moreover, the target population is not done in university students yet because adult workers (Bade et al., 2017; Kim & Yim, 2020; Lee & Kim, 2015) and female patients (Aboufazeli et al., 2021; Jeong et al., 2015) are usually selected in previous studies. The research should focus on university students specifically as the incidence of non-specific chronic LBP is increasing nowadays among university students due to the sedentary behaviour developed from online learning. This study is vital in physiotherapy as it provides scientific evidence to guide physiotherapists in formulating the best intervention to reduce LBP. Hence, the quality of life of university students with non-specific chronic LBP can be increased.

### 1.3 Research Objectives

1. To compare the effects of different gluteal strengthening programs on strength among university students with non-specific chronic low back pain
2. To compare the effects of different gluteal strengthening programs on pain among university students with non-specific chronic low back pain
3. To compare the effects of different gluteal strengthening programs on functional disability among university students with non-specific chronic low back pain
4. To compare the effects of different gluteal strengthening programs on balance among university students with non-specific chronic low back pain

## 1.4 Hypotheses

**Null hypothesis, $H_o$:**

There is no significant difference between two gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic low back pain.

**Alternative hypothesis, $H_l$:**

There is a significant difference between two gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic low back pain.

## 1.5 Research Question

Is there any significant difference between the effects of different gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic low back pain?

## 1.6 Rationale of Study

A series of recent studies have been conducted to investigate the effectiveness of gluteal strengthening exercises in the LBP population. However, the results are not consistent as some studies found that it is beneficial (Aboufazeli et al., 2021; Bade et al., 2017; Jeong et al., 2015; Lee & Kim, 2015) whereas some studies showed that this intervention does not show a significant improvement when compared to the conventional exercise (Fukuda et al., 2021;

Kendall et al., 2015). These studies have not been conducted on university students with non-specific chronic LBP yet as the researchers mostly targeted adult workers (Bade et al., 2017; Kim & Yim, 2020; Lee & Kim, 2015) and female patients in previous studies (Aboufazeli et al., 2021; Jeong et al., 2015). Research should focus university students as they are more prone to LBP nowadays due to decreased physical activity levels during the online study. Currently, there is a lack of research to evaluate which gluteal strengthening programs are more efficient in improving strength, pain, functional disability and balance among university students with non-specific chronic LBP.

Most of the research focused on strengthening the whole gluteal muscles group instead of targeting the specific gluteal muscles. Thus, this study is conducted by prescribing two different gluteal strengthening programs to two groups of participants to determine whether the SGSP or NGSP was more effective in improving strength, pain, functional disability and balance. The results generated from this study are essential for physiotherapists to formulate the best exercise program for managing of LBP based on scientific evidence. Hence, a proper intervention also improves the function and quality of life of university students who suffered from non-specific chronic LBP.

**1.7 Scope of study**

This study aims to determine whether the NGSP has more effects on strength, pain, functional disability and balance compared to the SGSP among university students with non-specific chronic LBP. This study focuses on university students aged between 18 and 25 years old from UTAR Sungai Long campus with non-specific chronic LBP. It will be conducted in the physiotherapy centre at UTAR Sungai Long campus for six weeks.

### 1.8 Operational definition

a. Effect refers to something that results from a cause or agency (Collins English Dictionary, n.d.).

b. Gluteal strengthening program is a program that consists of a variety of exercises to improve the strength of muscles around the hip to protect the hip joint from injury and degeneration (Inverarity, 2022).

c. Strength refers to the attribute of being strong including the capacity for effort endurance (Merriam-Webster, n.d.).

d. Pain is an irritating sensation and emotional experience brought by tissue damage (Felman, 2022).

e. Functional disability refers to the acquired difficulty in carrying out activities of daily living or more complicated tasks for independent life (Vaish et al., 2020).

f. Balance refers to maintenance of the body's centre of mass onto the foot-supported area in an upright and stable manner (Vaish et al., 2020).

g. University students are defined as students who enrolled in a university or college to pursue their studies (*University student*, n.d.).

h. Non-specific chronic LBP refers to pain and discomfort experienced at low back region lasting for 12 weeks or longer without a diagnosed pathology (NINDS, 2020).

### 1.9 Structure of research project

This research project was divided into five chapters. Chapter 1 outlines the background of the study, which consists of research questions, objectives and hypotheses. Then, Chapter 2 presents the literature review with a comparison of previous studies. Chapter 3 continued to discuss the research design, sampling design, research instrument and the procedure of the research process. Chapter 4 showed study results and hypothesis testing after completing the data analysis procedure. Lastly, Chapter 5 features a discussion of the results from the study, followed by the limitation of the present research and recommendations for future research. This chapter ended with a conclusion.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Chapter overview

This chapter builds the framework for the research project by exploring different themes through the previous studies relevant to the current study.

## 2.2 Prevalence of non-specific LBP among university students in Malaysia

According to Hussein et al. (2009), LBP accounts for 12% of the semi-rural population in Malaysia. It is a challenging problem for people of all ages as there is no clear evidence on the cause of LBP and its management. The prevalence of non-specific LBP is also rising among university students due to the change in learning style from physical to online mode. According to Anggiat et al. (2018), LBP among university students is related to their long sitting hours in daily life. However, Alshagga et al. (2013) suggested that LBP among university students is also caused by age, fitness level, intake of coffee, duration of computer use and sitting posture. Other risk factors of LBP among university students are also mentioned by Nordin et al. (2014), including gender, smoking, psychosocial factors and general health status.

Studies found that the younger population usually experiences LBP with a prevalence of 12% to 80% (Nordin et al., 2014). The majority of LBP among health science undergraduates, especially medical students in Malaysia is significantly higher than other musculoskeletal pain in Malaysia with a prevalence of 27.2% (Alshagga et al., 2013). This phenomenon can be explained by the prolonged study duration and improper sitting posture adopted by medical students in front of the computer during lecture classes. According to Lee et al. (2022), 31% of university students in Malaysia reported that they had spent more than 9 hours sitting in a day. They are more likely to develop LBP due to their sedentary behaviour which causes a reduction in lumbar activation (Morl & Bradl, 2013). The prolonged sitting habits also impair blood circulation and increase the workload in the stressed group of muscles at the back (Lee et al., 2022). All these factors will increase the risk of getting LBP.

Unfortunately, LBP has a significant impact on the functional and academic activities of the university population. A study reported that 30% of university students who experienced LBP had limitations in performing educational activities and their quality of life was also affected (Casas et al., 2016, as cited in Anggiat et al., 2018). This problem is less likely to cause functional severe disability in the younger population but having LBP in earlier life may cause recurrent and chronic LBP in future (Nordin et al., 2014). Hence, LBP was a serious problem among university students and a proper intervention that focused on a specific group of muscles should be given to address the pain.

## 2.3 Association of gluteal muscles and LBP

Some evidences showed an association between the gluteal muscles and LBP. Lee and Kim (2015) stated that the function of hip joint is closely related to LBP because the anatomical location of hip joint is close to the lumbopelvic area. Arokoski et al., (2004, as cited in Kim & Yim, 2020) claimed that the hip joint and low back carry out the same action although they serve different functions. Thus, treating one area can improve function and alleviate pain in the untreated part based on the relationship between the glutes and low back. However, the disability in nearby joints can directly and indirectly impact the musculoskeletal symptoms (Kim & Yim, 2020). For example, elderly patients with chronic LBP always complain of morning stiffness and pain in the hip joint.

Jeong et al. (2015) claimed that the pathology of the waist is associated with the weakening of gluteal muscles and functional disorder of the hip joint. The association between low back and hip joint also can be observed because athletes who suffer from LBP have a restricted range of motion in their hips (Yang et al., 2018, as cited in Kim & Yim, 2020). Patients who underwent total hip replacement surgery also found that their low back and gluteal pain intensity was reduced. Hence, the pain intensity and functional disability level among LBP patients can be reduced by adding gluteal exercise to the management program to support and improve the pelvis and lumbar spine mechanics (Kendall et al., 2015).

Lumbar segment dysfunction is one of the reasons that cause muscle weakness or spasticity around the hip joint (Lee & Kim, 2015). Lumbar segmental stability is significantly influenced by the ability to control gluteal muscles actively. The sacroiliac joint is essential as it transfers the loads from the trunk to the lower limb (Jeong et al., 2015). The activation of multifidus, transversus abdominis, internal oblique and gluteus maximus helps maintain the integrity of the sacroiliac joint, which in turn preserves the stability of the pelvis and lumbar spine (Kim & Yim, 2020). However, weakening of these muscles is often being noticed in patients with LBP, thus compromising the sacroiliac joint's stability.

According to Lee and Kim (2015), patients with LBP tend to compensate for the weakness of trunk by developing a rounded back posture with flexion of the hip, knee and ankle joints. This improper posture causes the gluteal muscles to become weak and undergo tension and lesion in the lumbopelvic region. The lumbopelvic region's instability may occur due to gluteus medius hypofunction (Neumann et al., 2002, as cited in Lee & Kim, 2015).

An evaluation of the hip joint in relation to LBP has been viewed as a crucial factor in choosing the course of treatment based on the correlation between the intensity of LBP and the restriction of hip joint function (Lee & Kim, 2015). This statement is supported by Fukuda et al. (2021), who claimed that the gluteal muscle is an essential consideration for managing LBP because it offers a stable base for the lumbar spine by maintaining the stability of the pelvis in the frontal and sagittal plane. Thus, adding a gluteal strengthening program to LBP patients is vital to increase pelvis stability as the limitation of gluteal range of motion and weakening of gluteal muscles are associated with LBP.

### 2.4 Effects of core stabilization exercise in non-specific LBP patients

Core stabilization exercise has become a well-known therapeutic intervention for managing LBP. In a recent study by Frizziero et al. (2021), the data suggested that core stabilization exercise is more effective than other exercises in treating chronic LBP. Several lines of evidence support this finding and the possible factor contributing to this result is the activation of core muscles through core stability exercise. Lumbar muscles comprise the deep and superficial stabilizer muscles that provide fundamental support to the low back and maintain lumbar segmental and core stability. Deep stabilizer muscles include the multifidus, transversus abdominis and internal oblique muscles whereas the superficial muscles include the erector spinae, rectus abdominis and external oblique muscles (Jeong et al., 2015). Hence, strengthening deep and superficial stabilizer muscles is necessary for the spine to return to its neutral posture and decrease the stress on the structures of the lumbar spine.

Besides that, Kendall et al. (2015) claimed that the range of motion of the trunk is reduced significantly in patients with LBP. This finding is due to the pain, inhibition of reflex muscle contraction mechanism and structural damage that occurs in patients with LBP (Jeong et al., 2015). Patients with LBP also frequently experience trunk muscle weakness particularly in their abdominal muscles (Jeong et al., 2015). Weakness in these muscles occurs because LBP is brought by an imbalance between the trunk extensor and abdominal muscles which weakens the stabilization of the lumbar segment (Jeong et al., 2015). Declined muscle strength and muscle atrophy also can be found in LBP patients due to a lack of trunk muscle use for an extended period. These conditions will exacerbate LBP and cause secondary lumbar segment damage and physical disability in daily life (Jeong et al., 2015). It is common to see patients with LBP presented with symptoms of decreased muscle strength, endurance and restricted range of motion of the lumbar segment (Jeong et al., 2015). As a result, core stabilization exercise effectively decreases LBP and improves lumbar stability by enhancing core muscle strength and movement adjustment capacity through the sensory-motor control mechanism.

### 2.5 Effects of gluteal strengthening exercise on trunk and gluteal muscle strength in non-specific LBP patients

Jeong et al. (2015) stated that the addition of gluteal strengthening exercise to lumbar stabilization exercise results in not only a significant improvement in the functional disability index but also the lumbar isometric muscle strength when compared to the prescription of lumbar stabilization exercise alone. Lumbar stabilization is an effective intervention in improving muscle strength and movement adjustment performance due to the activation of the sensory-motor mechanism (Jeong et al., 2015). However, the addition of gluteal strengthening exercise benefits LBP patients because it increases the stability of pelvis and lumbar spine by enhancing gluteal muscle strength (Kim & Yim, 2020). The study by Jeong et al. (2015) highlighted the effectiveness of the gluteal strengthening program in improving lumbar muscle strength. However, it only measures trunk muscle strength and targets middled-aged female patients with LBP specifically which cannot be generalized to the population nowadays. Besides that, Aboufazeli et al. (2021) found that the addition of gluteal abductor strengthening exercises not only reduced the pain intensity and physical disability in LBP patients but also increased the lumbar multifidus muscle thickness when compared to the conventional stabilization exercise. The lumbar multifidus muscle is often reduced in LBP patients. However, it increases after practising the lumbar stabilization and gluteal abductor strengthening exercise because dynamic exercises performed in different body orientations tend to recruit the fast twitch fibre of multifidus more effectively (Aboufazeli et al., 2021).

Fukuda et al. (2021) also assess the impact of standard treatment for LBP and the standard treatment with an addition of gluteal strengthening exercise to the gluteal extensor and gluteal abductor strength by using the hand-held dynamometer. The result showed that both gluteal extensor and gluteal abductor strength increased after completing the standard treatment with gluteal strengthening exercise but no significant difference was found between these two groups. This finding may be due to the short intervention period that need to be increased for motor learning. The gluteal extensor and gluteal abductor muscles are the two common muscles that are found to be weak in low back patients (Kim & Yim, 2020). These two muscle groups should be strengthened because they offer a stable base for the lumbar spine by maintaining the pelvis stability in the frontal and sagittal planes (Fukuda et al., 2021). Besides, gluteus maximus and gluteus medius strength have a positive correlation with core extensor endurance. Ambegaonkar et al. (2014) explained that this finding may be due to the attachment of the hamstring, quadriceps and iliopsoas muscles that shared the same anatomical areas as the core muscles. However, this relationship has yet to be studied in the population with non-specific chronic LBP. Hence, a NGSP explicitly targeted the gluteal maximus and gluteus medius was created to evaluate the impact of strengthening these two muscles on the trunk and gluteal muscles strength for LBP patients.

### 2.6 Effects of gluteal strengthening exercise on pain and functional disability in non-specific LBP patients

Various studies have assessed the effectiveness of gluteal strengthening exercises for patients with LBP. Bade et al. (2017) found that the pain score, functional disability and patient satisfaction level had improved significantly after the addition of gluteal strengthening program and gluteal mobilization to a pragmatic treatment of the lumbar spine for patients with LBP. Similarly, another study also reported that the combination of gluteal exercises and core stabilization exercises shows a significant improvement in functional disability and pain intensity for patients with chronic LBP (Lee & Kim, 2015). This finding is supported by the research of Aboufazeli et al. (2021) who found that the level of pain and functional disability decreased significantly after practising the gluteal abductor strengthening exercises compared to the conventional lumbar stabilization exercise. The functional disability encountered in LBP patients can be improved through the gluteal strengthening program because it improves function in daily life by enhancing the lumbar spine and pelvis mechanics (Kim & Yim, 2020).

However, research on this topic presents conflicting findings. Research by Fukuda et al. (2021) suggests that there is no significant improvement in pain and functional disability of chronic non-specific LBP patients when adding gluteal strengthening exercises to manual therapy and lumbar stabilization exercises compared to the intervention without a gluteal strengthening program. Kendall et al. (2015) found a similar finding, concluding that no remarkable effects on pain and functional disability level was observed between the groups that practise the open and closed kinetic chain of gluteal strengthening exercises together with conventional lumbar therapy and the groups that performed completing lumbopelvic exercise alone. Hence, this research study is vital to find out the efficacy of different gluteal strengthening programs on the pain and functional disability level among the LBP population.

## 2.7 Effects of gluteal strengthening exercise on balance in non-specific LBP patients

According to Jeong et al. (2015), LBP patients have poor balance ability compared with healthy people due to lumbar segmental instability which causes decreased muscle mobilization ability and postural adjustment. Stabilization muscles in the lumbar pelvic area such as the multifidus and transversus abdominis keep the body balanced throughout all body movements as they contract more quickly than the other lumbar muscles (Jeong et al., 2015). However, these muscles are affected and become unstable in patients with LBP. Therefore, a delay in reaction time to preserve balance and posture occurs when the body is exposed to a sudden load, thus reducing postural stability and balance performance. The balance performance of LBP may also result from the instability of the pelvis due to the weakening of gluteal muscles. This is because the gluteal muscles provide a stable base for the lumbar spine during all movements (Fukuda et al., 2021).

According to research done by Wilson et al. (2018), there was an association between the gluteal muscles and the Y-balance test scores. However, the gluteal abduction strength exhibited the strongest correlation compared to other gluteal actions. The finding may be due to the function of gluteus medius and gluteus minimus which serve as the major gluteal abductors. These two muscles help to stabilize the pelvis during a single leg stance by resisting the gravitational force and on unsupported leg and pelvis. This study is corroborated by a study conducted by Ambegaonkar et al. (2014) who found that participants with greater gluteal muscles strength achieved a better score in the star excursion balance test and Y balance test. This study showed that gluteal strengthening exercises might improve balance as gluteal muscles contribute to the postural stability of the lumbar spine. However, it only targeted female athletes which cannot be generalized to the population. As a result, this study is important to investigate the effects of different gluteal strengthening programs on balance among non-specific LBP patients.

## 2.8 Selection of gluteal strengthening program for non-specific LBP patients

Several studies have assessed the effectiveness of gluteal strengthening exercises in LBP patients but the results remain controversial. The conflicting finding occurs because different studies used different gluteal strengthening exercise programs thus leading to inconsistent results. A study by Fukuda et al. (2021) prescribed a gluteal strengthening exercise program comprising four gluteal exercises including clamshell, hip abduction, squatting and lateral stepping exercises for LBP patients. All exercises were carried out against an ankle weight resistance and were conducted for 10 sessions and 2 times per week for 5 weeks. A wide group of gluteal muscles was focused in this program such as the gluteal abductor, gluteal lateral rotators and gluteal extensor (Fukuda et al., 2010). The study showed improvement in pain, functional disability and gluteal extensor strength in the groups that practised core stabilization exercises together with gluteal strengthening exercises. However, there is no significant improvement when compared to the groups that performed core stabilization exercises alone. This finding may be due to the short study period, which is insufficient for developing motor learning (Fukuda et al., 2021). This program is used as the standard gluteal strengthening protocol in this research because it was proven to be effective in treating other conditions such as sacroiliac dysfunction (Added et al., 2018), patellofemoral pain (Lack et al., 2015) and acetabular labrum tears (Yazbek et al., 2011). More treatment sessions were added to the present study and the effect was compared with the intervention groups that received a NGSP targeting the specific gluteal muscles.

Gluteus maximus is a strong gluteal extensor and lateral rotator while gluteus medius is responsible for gluteal abduction to stabilize the femur and pelvis during weight-bearing exercises. (Reiman et al., 2012). Weakness and stiffness in gluteal muscles especially gluteal extensor is linked to a variety of low back and lower extremity pathologies (Kendall et al., 2015; Reiman et al., 2012). This finding is supported by Jeong et al. (2015) who found that the weakness of gluteus maximus causes LBP and sacroiliac joint dysfunction because the excessive sacroiliac joint movement will exert pressure on the joint and discs between the L5 to S1 vertebral body. This is because the gluteus maximus helps to control excessive movement of sacroiliac joint and stabilize the sacroiliac joint by contracting itself and inducing a self-locking mechanism (Jeong et al., 2015).

In addition, Cooper et al. (2016) found that patients with non-specific chronic LBP patients often presented with signs of gluteal abductor dysfunction such as gluteus medius weakness, tenderness and a positive Trendelenburg sign. Gluteus maximus and gluteus medius provide support to low back and maintain pelvis stability thus any weakness in these muscles will increase stress on the low back (Abbey, 2019). Strengthening exercises that targeting these two muscle groups proved to be effective in improving gluteal kinematics and strength. Thus, a NGSP is created by introducing two gluteal exercises that target the gluteus maximus and gluteus medius muscle specifically which are the forward step-up and dynamic side-bridge exercise. The literature review conducted by Reiman et al. (2012) states that forward step-up has the highest-level activation of gluteus maximus while side-bridge to neutral spine position activates gluteus medius the most because they achieved more than 60% of maximal voluntary isometric contraction of these muscles. However, side-bridge exercise was modified into dynamic side-bridge to be compared with the isotonic exercises under SGSP. This NGSP was given to intervention group in the present study to evaluate the effects on strength, pain, functional disability and balance compared to SGSP.

Although previous studies have found that gluteal strengthening exercises improve LBP significantly, other studies presented conflicting findings (Fukuda et al., 2021; Kendall et al., 2015). There is also lack of studies to compare the effects of different gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic LBP. Thus, after considering the strengths and limitations of each research, this study is conducted on university students as there needs to be more evidence on this research topic among university students with non-specific chronic LBP. Specific inclusion and exclusion criteria are also used to ensure the accuracy of results obtained and prevent confounding variables that may affect the outcome of the study.

# CHAPTER 3

# METHODS

## 3.1 Chapter overview

This chapter presents the research methodology, including the research design, sampling design, research instrument and procedure of conducting the present study.

## 3.2 Study Design

The research design for this study was a randomized controlled trial conducted in a single-blinded manner which the outcome assessor was blinded to minimize bias (Penic et al., 2020). The participants were assigned into two groups which are the control and intervention group. The independent variable in this study is the type of gluteal strengthening program while the dependent variable refers to the strength, pain, functional disability and balance performance among university students with non-specific chronic LBP. The dependent variable will be the outcome measures that were taken at the baseline and after the completion of 4-weeks intervention to study the impact of different gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic LBP.

### 3.3 Study Setting

This study was conducted at Physiotherapy Centre in UTAR, KA Block 3rd floor, Sungai Long campus in Selangor.

### 3.4 Study population

The population for this study is university students in UTAR Sungai Long campus who are aged between 18 to 25 years old.

### 3.5 Sample size

The sample size was determined using G*Power 3.1 software. The sampling size was calculated with the effect size set as 0.25, alpha of 0.05 and power of 0.8. The results showed that 34 participants were needed for this study. However, an additional 10 per cent of the total participants, which is an additional 2 participants were added to compensate the study dropout rate and equalize the number of participants for both groups. Hence, a total of 36 participants were recruited to conduct this study and they were divided evenly into two groups with 18 participants in each group.

### 3.6 Sampling method

Simple random sampling was employed as the sampling method to recruit the participants with non-specific chronic LBP because it provides a high validity to this study and shows a better presentation of the studied population (Thomas, 2022).

### 3.7 Inclusion criteria

1. University students who enrolled in a certified course in UTAR Sungai Long campuses
2. Age 18 to 25 years old (Anggiat et al., 2018)
3. Experience low back pain that persisted for at least 3 months without radicular pain into lower limb (Lee & Kim, 2015)
4. Experience a low back pain intensity of at least a score of 3 on VAS (Kim & Yim, 2020)

### 3.8 Exclusion criteria

1. Participants with a history of injury or surgery to lumbar spine, abdomen, pelvis or lower limb for past 1 year (Kendall et al., 2015)
2. Participants with known spinal deformities (eg. scoliosis, spondylolysis, spondylolisthesis, spinal stenosis or prolapsed intervertebral disc etc), spinal inflammation or signs of neurological deficits (Nordin et al., 2014)
3. Participants with a history of spinal and pelvic fracture for the past 3 months (Kim & Yim, 2020)
4. Participants who are taken corticosteroids or anti-inflammatory medication currently (Kim & Yim, 2020)

## 3.9 Instrumentation

### 3.9.1. Participant recruitment form

A participant recruitment form was used before the intervention started to collect the demographic data of the participants and determine their eligibility to participate in this study. The questionnaire was divided into four sections which the first section was the informed consent section that provided a brief introduction regarding the study background and the purpose of study. The second section was the personal data protection statement which require the participants to state their agreement to be involved in this study. It was followed by a demographic data section and the last section was the screening tool which contains a series of screening questions to include and exclude the participants based on the inclusion and exclusion criteria.

### 3.9.2 Hand-held dynamometer

The primary outcome measure which are the isometric muscle strength was measured with a hand-held dynamometer because it demonstrated a high intra and inter-tester reliability for trunk muscular strength assessment with an interclass correlation coefficient (ICC) of 0.84 to 0.96 (Karthikbabu & Chakrapani, 2017). The muscle strength that was being tested includes the trunk extension, trunk flexion, trunk rotation, gluteal extension and gluteal abduction of dominant and non-dominant side. The participants were placed in a proper position and they were instructed to exert their maximum force against the dynamometer. For trunk extension strength, the participants were assessed in prone position and they were asked to lift their chest off the bed against the dynamometer which was placed at their T4 area. Then, the trunk flexion strength of the participants was measured in supine position and they were instructed to lift their scapula off the bed against the dynamometer which was placed on their sternum. The dominant trunk rotation strength was measured in supine position and the participants were asked to raise the dominant side of scapula off the bed towards their opposite knee against the dynamometer that was placed over their pectoralis muscle. The same procedure was repeated for the non-dominant side of pectoralis muscle to measure the trunk rotation strength of non-dominant trunk (Karthikbabu & Chakrapani, 2017).

After that, the strength of gluteal extension and abduction of both dominant and non-dominant leg were being measured with the hand-held dynamometer because it has a good validity and reliability with an ICC between 0.62 to 0.93 (Bazett-Jones & Squier, 2020). Firstly, the dominant gluteal extensors strength was measured in prone position with the dominant knee flexed and the participants were asked to extend their hip of dominant leg against the dynamometer which was placed at 5cm proximal to popliteal fossa (Thorborg et al., 2010). The non-dominant gluteal extensor strength was measured using the similar procedure with the exchange of dominant to non-dominant leg. Then, the participants turned to a side-lying position on the non-dominant side to measure the strength of dominant gluteal abductor strength. The therapist stabilized the participants' hip while applying resistance at 5cm proximal to lateral malleolus with the dynamometer against the hip abduction performed by the participants (Thorborg et al., 2010). The non-dominant gluteal abduction strength was being measured with the same placement of the dynamometer at non-dominant leg but the participants was positioned to side-lying on their dominant side. Each muscle was tested for 3 times and the average score was recorded to obtain an accurate result.

### 3.9.3 Visual Analogue Scale (VAS)

VAS is an instrument used to measure an element that comes with a range of values that cannot be measured directly (*Visual analogue scale*, 2022). In this study, VAS was used to measure the amount of pain experienced by the participants at the low back region. It contains a scale ranged from “0” which indicates no pain to an extreme level of pain which was represented by a score of “10”. The participants were asked to rate their intensity of LBP in the google form given before and after the intervention to compare the effectiveness of the two gluteal strengthening programs on LBP intensity. VAS was used in this study because it has a high sensitivity to small changes and only simple procedures were required (*Visual analogue scale*, 2022). According to Bijur et al. (2001), VAS is a scale that has a high validity and reliability to assess the chronic pain intensity as it has an ICC of 0.97 with 95% of confidence interval.

### 3.9.4 Oswestry Disability Index (ODI)

ODI was being used to evaluate the level of permanent functional disability induced by LBP. Kim and Yim (2020) claimed that ODI contains 10 questions ranging from the intensity of pain, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life to traveling that can be answered in 5 minutes. This questionnaire in google form was answered by the participants before and after interventions. Then, the final score was divided by

50 then multiplied with 100 to get the percentage score of the permanent functional disability of the participants. Based on the scoring, the participants were categorized into 5 groups which were the minimal disability (0-20%), moderate disability (21-40%), severe disability (41-60%), crippled (61-80%) and exaggeration of symptoms group (81-100%). According to Fairbank and Pynsent (2000), the patient in minimal disability group can still perform most living activities without receiving any treatment whereas the exaggeration of symptoms group is the most serious group where the patients are usually bed-bound. It is considered the gold standard assessment for low back functional outcomes (Fairbank & Pynsent, 2000). According to Davidson and Keating (2002), ODI is a validated scale with a high test-retest reliability because it has an ICC greater than 0.80 with 95% of confidence interval which is suitable to measure acute and chronic LBP.

### 3.9.5 Y-balance test

The balance performance of participants was measured by Y Balance Test. The participants were instructed to stand on one leg and used another leg to push the reach indicator box as far as they could in forward, posterolateral and posteromedial directions. Y-balance test score of both dominant and non-dominant leg was taken to determine whether the leg dominancy affect balance performance. The method to assess the dominance of a leg includes questioning the participants which leg they preferred to kick a ball (Schorderet et al., 2021). Some functional tests were carried out to assess the leg they used to initiate a step or the leg they used to kick a ball if the participants was uncertain about their dominant leg. For the Y-balance test procedure, 6 practice trials were done before completing the 3 testing trials so that the participants were familiar with the testing procedures (Wilson et al., 2018). The researcher demonstrated and explained the procedure to each participant before the test began. For the scoring system, 3 reach distances in each direction in cm were added and the value was divided by 3 to get the average reach distance. Then, the value of absolute reach distance is divided by limb length of interest then multiplied by 100 to obtain the percentage score of normalized reach distance (Walker, 2016). Limb length refers to the distance between the anterior superior iliac spine and the medial malleolus of the tested leg. The composite score was calculated by dividing the total maximum reaches in three directions by three times of leg length then multiply by 100. According to Walker (2016), Y Balance Test has a high test-retest reliability as the composite score has an intrarater reliability of 0.91 and an interrater reliability of 0.99.

### 3.10 Procedure

Following the ethical approval from the UTAR Scientific and Ethical Review Committee (SERC), the study was initiated. The participants were recruited through a simple random sampling method and they underwent the initial screening through a participation recruitment form to determine their eligibility to participate in this study. For the eligible participants, they were given a brief introduction about the background of study and their demographic data was collected through Google form. The participants who met the inclusion criteria was provided an informed consent form which contains all risks and benefits of this study. The personal data protection statement was explained to each participant so that they understood their personal information will not be disclosed to the public.

A total of 36 participants were selected and they were randomly distributed into a control group (n=18) and an intervention group (n=18). This randomization procedure for group allocation was conducted by drawing lots because it is considered a fair way to decide which group the participants belong to (Silverman & Chalmers, 2001). 36 pieces of paper were prepared with 18 of them being labelled as "control group" while the remaining 18 pieces labelled as "intervention group". All papers were folded into equal shapes and the participants were instructed to choose one of them. The result was revealed directly and the group allocation was recorded by the researcher. Then, a short briefing was given to the participants based on the exercise program that they were assigned to. Each participant was given a booklet that contains the exercise guideline and frequency that they need to perform for the following 4 weeks. They were asked to bring their booklet to the physiotherapy centre during each intervention session and their attendance was marked by researcher at the last page of the booklet to track their attendance.

Before the intervention starts, a pre-test measurement was conducted and the result was recorded by an outcome assessor who did not have knowledge about the group allocation. The participants underwent an assessment of trunk and gluteal muscles strength using a hand-held dynamometer, pain intensity measured by VAS, functional disability level measured by ODI and balance performance which was assessed by Y-balance test. After completing the pre-test measurement, the intervention for both groups was began with a warm-up procedure that include brisk walking and stretching of both upper limb and lower limb for 5 minutes. All the exercises were performed on a mat and demonstrated by the researcher.

After the warm-up session, the participants in both control and intervention groups performed the same core stability exercises based on McGill core stabilization program that comprised of 3 exercises which include the curl-up, side plank and bird-dog exercise (Ghorbanpour et al., 2018). A rest period of 1 minutes was given between each exercise. The details of three exercises included in McGill core stabilization program was stated as follows.

i. Modified curl-up (Horschig & Sonthana, 2018)

The participants lied supine with one knee bent and the other kept straight. The participants were instructed to place their hands behind low back and pick their head off the ground for a few inches. The position was maintained for 10 seconds then relaxed the head back down on ground. This exercise was performed for a frequency of 3 sets of 10 repetitions.

ii. Side plank (Horschig & Sonthana, 2018)

The participants were positioned in side-lying with both knees bent while the upper trunk was supported through his elbow. Then, the hips were raised so that the body weight was supported by knee and arm. The position was maintained for 10 seconds then returned back down on ground. The same exercise was repeated on the other side. This exercise was performed for a frequency of 3 sets of 10 repetitions.

iii. Bird dog (Horschig & Sonthana, 2018)

The participants were positioned in quadruped with a neutral alignment of spine. They were instructed to kick one of the legs backwards while lifting the opposite side arm simultaneously until both extremities were straightened. The position was maintained for 10 seconds and there should not be any movement at the low back. Then, they returned back to the quadruped position and switch side. This exercise was performed for a frequency of 3 sets of 10 repetitions for each side.

After that, the SGSP adapted from previous research was prescribed for the control group because it is an effective protocol applied in many researches to strengthen the gluteal muscles (Fukuda et al., 2021). This SGSP includes the clamshell, hip abduction in side-lying position, squatting and lateral stepping exercise. All the exercises were done against a resistant band of equal resistant tied around their ankle or knee region. The details of the exercises included in SGSP was stated as follows.

i. Clamshell with resistant band (Fukuda et al., 2021)

Patient was positioned in side-lying with both knees slightly bent and a resistant band was tied around both thighs. Their feet were kept together and the top knee was lifted up without moving the feet. Then, the knee was lowered down to starting position and switch side. This exercise was performed for a frequency of 3 sets of 10 repetitions for each side.

ii. Side-lying hip abduction with resistant band (Fukuda et al., 2021)

Patient was positioned in side-lying with both legs extended and a resistant band was tied at the thigh region. The top leg was raised as high as they could then lowered it back down. The same procedure was repeated at the different side and this exercise was performed for a frequency of 3 sets of 10 repetitions for each side.

iii. Squat with resistant band (Fukuda et al., 2021)

Participants were instructed to tie the resistant band just above the knees and stood up with both feet slightly wider than hips. Then, their body was lowered down gradually into squat position while pushing the hips back. The participants then stood up again and released the band slightly. This exercise was performed for a frequency of 3 sets of 10 repetitions.

iv. Lateral stepping with resistant band (Fukuda et al., 2021)

A resistant band was tied on the participants' both legs. Then, they stood up with their feet placed at shoulder-width position. They were instructed to slightly bend their knees while lifting chest then step to the left side until the set was completed. The stance should exceed shoulder-width during side step and the same procedure was repeated by stepping to the right side. This exercise was performed for a frequency of 3 sets of 10 repetitions for each side.

In contrast, the intervention group practised a NGSP that consists of the forward step-up and dynamic side-bridge to activate gluteus maximus and gluteus medius respectively (Reiman et al., 2012). A break time of 1 minute was given to the participants between each exercise. Only two exercises were included in NGSP but its exercise frequency was the same as the SGSP for fair comparison. The details of two exercises included in NGSP was stated as follows.

i. Forward step up (Reiman et al., 2012)

   The participants stood behind the bench which is 20cm tall and then placed their left foot on top of the bench and pushed through the other leg to raise body up onto the bench. Then, they were instructed to step down slowly with left leg and switch side. This exercise was performed for a frequency of 6 sets of 10 repetitions.

ii. Dynamic side bridge (Reiman et al., 2012)

   Participants were positioned on left side-lying with left forearm resting on the floor. They were asked to lift their pelvis up until the body formed a straight line then allowed the hips to dip until they were close to touching the floor. Then, they were instructed to return to the starting position and switch side. This exercise was performed for a frequency of 6 sets of 10 repetitions for each side.

Then, a 5-minutes cool-down session that includes the same exercises as warm-up was given for both groups. The duration of the control group exercise session in average was 30 minutes while the duration of intervention group exercise session was approximately 20 minutes including the warm-up and cool-down session. The intervention was conducted for 4 weeks and the participants attended the session 3 times per week for 4 weeks. The participants were informed that they were not allowed to participate in any other sports before the post-test measurement or during the research period. The post-test measurement was taken within two to three days after the last day of intervention. The post-test measurement was done by the outcome assessor and the outcome variables includes the strength, pain, functional disability and balance. After that, data analysis will be carried out for further interpretation.

### 3.11 Data analysis and statistical test

All the data collected was recorded into Microsoft Office Excel 2019 and the data was transferred into IBM Statistical Package for Social Science (SPSS) software version 20 for the data analysis procedure. A descriptive statistic was used to illustrate the demographic data obtained from the participants and the characteristic between groups was compared with an independent-samples t-test. A normality test was used to determine whether the data is normally distributed to run the parametric test. The difference in outcome variables between control and intervention group was measured with an independent-sample t-tests. Then, a paired-samples t-test was used to evaluate the differences within group at two different time points which was during pre-test and post-test results in this study (Mishra et al., 2019).

### 3.12 Ethical approval

This study is subjected to ethical approval from UTAR Scientific and Ethical Review Committee (SERC). The letter of information attached in Appendix A was provided after the approval. All the participants were informed that their information was kept confidential and their participation was voluntary. They have the right to withdraw from the study at any time.

# CHAPTER 4

# RESULTS

## 4.1 Chapter overview

This chapter presents the findings of this research process after completing the data collection process. The first section discussed demographic data of all participants. The following section presents each outcome measures ranging from trunk and gluteal strength, pain, functional disability and balance. The relationship of the variables was analysed using the inferential tests and the hypothesis testing was conducted. The results were presented as mean (M) and standard deviation (SD) and a there is a brief conclusion at the end of each paragraph to summarize the results of each variable.

A total of 36 participants was recruited at the beginning of this study. They were divided into control and intervention groups. Then, the participants in each group were further categorized into males and females for each group. All their characteristics was compared and analysed with the use of statistical test according to their group.

## 4.2 Normality test

A normality test was done for all the variables which include the demographic data of participants, trunk and muscle strength, VAS score, ODI score and Y-balance test score. The results of Kolmogorov-Smirnov and

Shapiro-Wilk statistics showed that all the variables have a p-value of greater than 0.05 which indicates normality. Hence, parametric test can be conducted because it is assumed that the populations from which the samples are taken are normally distributed.

### 4.3 Demographic of population

This section will discuss the demographic data of the participants including the age, height, weight and BMI with a descriptive statistic as shown in Table 4.1. Then, an independent-samples t-test was used to compare the participants' characteristics with respect to their group and the result was presented in Table 4.2 in terms of M and SD.

**Table 4.1: Demographic data of participants**

| Variables | n (%) | Mean (SD) |
|---|---|---|
| Age | | 20.94 (1.76) |
| Sex | | |
| Male | 14 (38.9) | |
| Female | 22 (61.1) | |
| Height | | 1.65 (0.49) |
| Weight | | 55.84 (8.90) |
| BMI | | 20.51 (2.69) |

BMI: body mass index, SD: standard deviation

### 4.3.1 Age

An independent-samples t-test was conducted to compare the age of participants between groups and the result was presented in Table 4.2. the difference in age of males in control group (M = 20.13, SD = 2.03) and males in intervention group (M = 22.00, SD = 2.00; t (12) = -1.72, p = 0.111. two-tailed). The results showed that there was no significant difference in age between these two groups. The same test is used to compare the age of males in control group and females in control group (M = 21.30, SD = 1.64; t (16) = 0.083, p = 0.192. two-tailed) but no significant relationship in age was found between these two groups. There was also no significant difference in age between females in control group and females in intervention group (M = 20.67, SD = 1.37; t (20) = 1.37, p = 0.335). The independent-samples t-test also showed that there was no significant difference in age between males in intervention group and females in intervention group (M = 22.00, SD = 2.00; t (16) = 0.723, p = 0.114. two-tailed). Hence, the result stated that no significant differences in age was found between all groups of participants.

### 4.3.2 Height

The height of participants was being compared with an independent-samples t-test with respect to the group that they belong to. As shown in Table 4.2, the height between males in control group (M = 1.73, SD = 0.064) and males in intervention group (M = 1.70, SD = 0.046; t (12) = 1.220, p = 0.246. two-tailed) was being compared and no significant difference was found between these two groups. There was also no significant difference found in the height between females in control group (M = 1.60, SD = 0.056) and females in intervention group (M = 1.61, SD = 0.049; t (20) = -0.456, p = 0.653). However, the independent-samples t-test showed that there was a significant difference in height for males and females in intervention group (t (16) = 3.623, p = 0.002. two-tailed) as well as the height for males in control group and females in control group (t (16) = 4.748, p <0.001. two-tailed). Hence, a significant difference in height was only found between males in control and intervention group and height between females in control and intervention group.

### 4.3.3 Weight

An independent-samples t-test was applied to compare the weight between males in control group (M = 62.63, SD = 9.01) and males in intervention group (M = 61.50, SD = 4.64; t (12) = 0.278, p = 0.786, two-tailed). There was no significant difference in weight between these two groups. Same result was obtained between weight of females in control group and females in intervention group (M = 52.84, SD = 7.05; t (20) = -0.688, p = 0.499). However, there was a significant difference in weight between males and females in control group (M = 50.60, SD = 8.22; t (16) = 2.957, p =0.009. two-tailed) as well as the weight between males and females in intervention group (M = 52.84, SD = 7.05; t (16) = 2.708, p = 0.016. two-tailed). Hence, a significant difference in weight was only found between males and females in control and also weight between females in control and intervention group.

### 4.3.4 BMI

BMI was also compared between groups with an independent-samples t-test and the finding was illustrated in Table 4.2. No significant difference in BMI was detected between the males in control group (M = 20.83, SD = 2.67) and males in intervention group (M = 21.40, SD = 1.57; t (12) = -0.460, p = 0.654, two-tailed) as well as the BMI between males in control group and females in control group (M = 19.85, SD = 3.54; t (16) = 0.647, p = 0.527. two-tailed). Similar result was found in BMI between females in control group and females in intervention group (M = 20.40, SD = 2.50; t (20) = -0.420, p = 0.679) as well as the BMI between males in intervention group and females in intervention group (M = 20.40, SD = 2.50; t (14.876) = 1.035, p = 0.317, two-tailed). Thus, no significant difference in BMI was found between all groups.

**Table 4.2 Comparison of participants' characteristics between groups**

| | Intervention | | Control | |
|---|---|---|---|---|
| | Male (N=6) | Female (N=12) | Male (N=8) | Female (N=10) |
| Age, year | 22.00 ± 2.00 | 20.67 ± 1.37 | 20.13 ± 2.03 | 21.30 ± 1.64 |
| Height, m | 1.70 ± 0.05 | 1.61 ± 0.05 [a] | 1.73 ± 0.06 | 1.60 ± 0.06 [b] |
| Weight, kg | 61.50 ± 4.64 | 52.84 ± 7.05 [a] | 62.63 ± 9.01 | 50.60 ± 8.22 [b] |
| BMI, $kg/m^2$ | 21.39 ± 1.57 | 20.39 ± 2.50 | 20.83 ± 2.67 | 19.85 ± 3.54 |

BMI: body mass index

[a] significant difference between males in intervention group (IM) and females in intervention group (IF), [b] significant difference between males in control group (CM) and females in control group (CF).

## 4.4 Characteristics of population based on the outcome measure scores

This subsection compared the results of the participants in each outcome measure that was taken both before and after the 4 weeks of intervention. A total of 4 outcome measures were discussed under this section which the first outcome to be featured is the muscle strength test that comprised of the trunk and gluteal muscle strength. This is followed by the VAS score, ODI score and the last outcome was the Y-balance test score. There are two statistical tests applied in this study which are the independent-samples t-test and paired-samples t-test. An independent-samples t-test was used to compare the results between different groups of participants whereas the difference between pre and post-test as well as the difference between dominant and non-dominant limb of each group were determined using a paired-samples t-test.

### 4.4.1 Muscle strength test

#### 4.4.1.1 Trunk extension strength

For the pre-test measurement of trunk extension strength, an independent-samples t-test was applied to compare the difference in strength between groups and the results were presented in Table 4.3. The trunk extension strength between males in control group (M = 8.74, SD = 1.70) and males in intervention group (M = 6.91, SD = 1.18; t (12) = 2.254, p = 0.054. two-tailed) was being compared and the result showed that there was a no significant difference between these two groups. No significant difference in trunk extension strength was also found between males in control group and females in control group (M = 8.24, SD = 1.84; t (16) = 0.589, p =0.564. two-tailed) as well as the strength between females in control group and females in intervention group (M = 7.32, SD = 2.09; t (20) = 1.088, p = 0.290, two-tailed). The finding suggests that the trunk extension strength of males in intervention group was not significantly different from the strength of females in intervention group (M = 7.32, SD = 2.09; t (16) = -0.441, p = 0.665, two-tailed) Hence, no significant difference was found in the pre-test of trunk extension strength between groups.

The post-test measurement of trunk extension strength was taken following intervention. The difference in the strength between males in control group (M = 9.68, SD = 1.89) and males in intervention group (M = 9.03, SD = 1.02; t (12) = 0.765, p = 0.459. two-tailed) was analysed using an independent-samples t-test and the result showed that no significant difference was found between these two groups. There was also no significant difference in the trunk extension strength between males in control group and females in control group (M = 9.48, SD = 2.27; t (16) = 0.201, p =0.843. two-tailed) as well as the strength between males in intervention group and females in intervention group (M = 9.07, SD = 2.13; t (16) = -0.055, p = 0.957, two-tailed). There was also no significant difference found between the females in control group and females in intervention group (t (20) = 0.441, p = 0.664, two-tailed). As a result, no significant difference was found between all groups during the post-test of trunk extension strength measurement.

After collecting the data for pre-test and post-test, a paired-samples t-test was used to evaluate the impact of the two different gluteal strengthening programs on the participants' trunk extension strength. The trunk extension strength of males in control group increases from the baseline (M = 8.74, SD =

1.70) to post-intervention (M = 9.68, SD = 1.89), t (7) = -1.065, p = 0.032 (two-tailed) whereas the strength for males in intervention group increases from the baseline (M = 6.91, SD = 1.18) to post-intervention (M = 9.03, SD = 1.02), t (5) = -3.262, p = 0.022 (two-tailed). Females in control group showed a marked increase in trunk extension strength from baseline (M = 8.24, SD = 1.84) to post-intervention (M = 9.48. SD = 2.27), t (9) = -1.562, p = 0.015 while the strength for females in intervention group also increases from baseline (M = 7.32, SD = 2.09) to post-intervention (M = 9.07, SD = 2.13), t (11) = -3.175, p = 0.009 (two-tailed). Hence, there was a statistically significant increase in trunk extension strength for all groups following intervention.

#### 4.4.1.2 Trunk flexion strength

As presented in Table 4.3, the pre-test measurement of trunk flexion strength between males in control group (M = 5.60, SD = 0.88) and males in intervention group (M = 4.33, SD = 1.54; t (12) = 1.956, p = 0.111. two-tailed) was being measured by an independent-samples t-test and the result suggest that there was no significant difference in strength between these two groups. There was also no significant difference in trunk flexion strength observed between males in control group and females in control group (M = 5.59, SD = 2.15; t (12.476) = 0.020, p =0.984. two-tailed) as well as the strength between the males in intervention group and females in intervention group (M = 3.68, SD = 1.13; t (16) = 1.037, p = 0.315, two-tailed). Similar result was obtained in the trunk flexion strength between females in control group and females in intervention group (M = 3.68, SD = 1.13; t (13.033) = 2.530, p = 0.055, two-tailed). Hence, the findings revealed that no significant difference in pre-test measurement of trunk flexion strength was found in all groups.

For the post-test measurement, the difference in trunk flexion strength between males in control group (M = 6.43, SD = 1.36) and males in intervention group (M = 5.07, SD = 1.39; t (12) = 1.833, p = 0.092. two-tailed) was measured with an independent-samples t-test and the result suggests that there was no significant difference in trunk flexion strength between these two groups. There was no significant difference in trunk flexion strength between males in control group and females in control group (M = 6.80, SD = 1.89; t (16) = -0.470, p = 0.644. two-tailed) as well as the strength between males in intervention group and females in intervention group (M = 4.85, SD = 1.50; t (16) = 0.302, p = 0.767, two-tailed) during post-test. the trunk flexion strength of females in control group also not significantly different from females in intervention group (t (20) = 2.707, p = 0.054, two-tailed). As a result, there was no significant difference in post-test measurement of trunk flexion strength for all groups.

A paired-sample t-test was conducted to evaluate the impact of the two different gluteal strengthening programs on the participants' trunk flexion strength. Strength of males in control group increases from the baseline (M = 5.60, SD = 0.88) to post-intervention (M = 6.43, SD = 1.36), t (7) = -2.056, p = 0.049 (two-tailed) whereas the strength also increases among males in intervention group from the baseline (M = 4.33, SD = 1.54) to post-intervention (M = 6.10, SD = 1.93), t (5) = -2.916, p = 0.033 (two-tailed). Females in control group showed a significant increase in trunk flexion strength from baseline (M = 5.59, SD = 2.15) to post-intervention (M = 6.80, SD = 1.89), t (5) = -2.979, p = 0.015 (two-tailed) which is similar for the strength for females in intervention group that increases from baseline (M = 3.68, SD = 1.13) to post-intervention (M = 4.85, SD = 1.50), t (11) = -3.123, p = 0.010 (two-tailed). Therefore, it is obvious that there is a statistically significant increase in trunk flexion strength for all groups following intervention.

#### 4.4.1.3 Dominant trunk rotation strength

For the pre-test of dominant trunk rotation strength, there was no significant difference between males in control group (M = 5.26, SD = 1.50) and males in intervention group (M = 4.57, SD = 0.91; t (12) = 0.990, p = 0.342. two-tailed) based on the results of the independent-samples t-test. The strength between males in control group and females in control group (M = 4.86, SD = 1.43; t (16) = 0.545, p =0.593. two-tailed) was also compared and the result showed that no significant difference was detected in these two groups. As shown in Table 4.3, there was also no significant difference in pre-test of dominant trunk rotation strength between males in intervention group and females in intervention group (M = 3.81, SD = 1.29; t (16) = 1.292, p = 0.215, two-tailed) as well as the strength between females in control group and females in intervention group (t (20) = 1.853, p = 0.079, two-tailed). Thus, there was no significant difference was noticed in the pre-test measurement of dominant trunk rotation strength between all groups.

The post-test of dominant trunk rotation strength was also measured and the difference in dominant trunk rotation strength was analysed with an independent-samples t-test. There was no significant difference in the dominant trunk rotation strength between males in control group (M = 6.31, SD = 1.21) and males in intervention group (M = 6.71, SD = 1.24; t (12) = -0.601, p = 0.559. two-tailed). The strength between males in control group and females in control group (M = 5.71, SD = 1.41; t (16) = 0.96, p =0.351, two-tailed) were also compared and the result showed that no significant difference was detected between these two groups. There was also no significant difference in the dominant trunk rotation strength found between females in control group and females in intervention group (t (20) = 1.006, p = 0.326, two-tailed) as well as the strength between males in intervention group and females in intervention group (M = 5.07, SD = 1.54; t (16) = 2.261, p = 0.058, two-tailed). As a result, there was no significant difference in the dominant trunk rotation strength between all groups.

The difference between pre and post-intervention period was measured with a paired-samples t-test to evaluate the effect of two different interventions on the dominant trunk rotation strength. The dominant trunk rotation strength for males in control group increases from the baseline (M = 5.26, SD = 1.50) to post-intervention (M = 6.31, SD = 1.22), t (7) = -3.706, p = 0.008 (two-tailed) whereas the strength for males in intervention group increases from baseline (M = 4.58, SD = 0.91) to post-intervention (M = 6.71, SD = 1.24), t (5) = -3.914, p = 0.011 (two-tailed). Females in control group have a marked increase in dominant trunk rotation strength from baseline (M = 4.89, SD = 1.43) to post-intervention (M = 5.71, SD = 1.41), t (9) = 0.002, p = 0.004 (two-tailed) while the strength for females in intervention group also increases from baseline (M = 3.81, SD = 1.29) to post-intervention (M = 5.07, SD = 1.54), t (11) = -4.194, p = 0.001 (two-tailed). In short, the dominant trunk rotation strength in all groups increases significantly from pre-test to post-test period.

#### 4.4.1.4 Non-dominant trunk rotation strength

The pre-test of non-dominant trunk rotation strength was measured with an independent-samples t-test and the result was presented in Table 4.3. No significant difference in strength was found between males in control group (M = 5.12, SD = 0.47) and males in intervention group (M = 4.29, SD = 1.14; t (12) = 1.872, p = 0.086. two-tailed). The difference in non-dominant trunk rotation strength between the males in control group and females in control group (M = 4.70, SD = 1.03; t (16) = 0.115, p = 0.304. two-tailed) were being measured and the result showed that no significant difference was found between these two groups. There was also no significant difference in non-dominant trunk rotation strength between males in intervention group and females in intervention group (M = 4.17, SD = 1.10; t (16) = 0.759, p = 0.835, two-tailed) as well as the strength between females in control group and females in intervention group (M = 4.17, SD = 1.10; t (20) = 0.0485, p = 0.263, two-tailed). As a result, there is no significant different in pre-test measurement of non-dominant trunk rotation strength between all groups.

The difference in non-dominant trunk rotation strength after intervention was analysed using an independent-samples t-test between males in control group (M = 5.90, SD = 0.68) and males in intervention group (M = 6.43, SD = 1.42; t (12) = -0.927, p = 0.372. two-tailed). There was no significant difference found in the strength between these two groups. The non-dominant trunk rotation strength between males in control group and females in control group (M = 5.83, SD = 1.39; t (16) = 0.146, p =0.886. two-tailed) was being compared and the result showed that no significant difference was detected between these two groups. There was no significant difference found in the non-dominant trunk rotation strength between males in intervention group and females in intervention group (M = 5.79, SD = 1.02; t (16) = 1.111, p = 0.283, two-tailed) as well as the strength between the females in control group and females in intervention group (t (20) = 0.073, p = 0.943, two-tailed). In short, it was cleared that no significant difference was found in non-dominant trunk rotation strength between all groups during the post-test period.

A paired-samples t-test was conducted to evaluate the impact of the two different gluteal strengthening programs on the participants' non-dominant trunk rotation strength. The strength of males in control group increases from the baseline (M = 5.12, SD = 0.47) to post-intervention (M = 5.90, SD = 0.68), t (7) = -3.189, p = 0.015 (two-tailed) whereas the strength for males in intervention group increases from the baseline (M = 4.29, SD = 1.14) to post-intervention (M = 6.43, SD = 1.43), t (5) = -5.889, p = 0.002 (two-tailed). The females in control group showed a marked increase in non-dominant trunk rotation strength from baseline (M = 4.70, SD = 1.03) to post-intervention (M = 5.83, SD = 1.39), t (5) = -2.835, p = 0.020 (two-tailed) while the strength for females in intervention group also increases from baseline (M = 4.17, SD = 1.10) to post-intervention (M = 5.79, SD = 1.02), t (11) = -5.173, p < 0.001 (two-tailed). Hence, the finding showed that there was a statistically significant increase in non-dominant trunk rotation strength for all groups.

The difference between dominant and non-dominant trunk rotation strength was analysed using a paired-samples t-test at pre-test and post-test period. The results of pre-test showed there was no significant difference was found between dominant trunk (M = 4.56, SD = 1.39) and non-dominant trunk (M = 4.55, SD = 1.01; t (35) = -0.05, p = 0.961). For post-test result, there was also no significant difference observed in dominant trunk (M = 5.61, SD = 1.51) and non-dominant trunk (M = 5.77, SD = 1.24; t (35) = 0.559, p = 0.580). Hence, no significant difference between dominant and non-dominant trunk rotation strength was observed for all groups during pre-test and post-test period.

**Table 4.3: Strength of trunk muscles**

| | Intervention | | Control | |
|---|---|---|---|---|
| | Male (N=6) | Female (N=12) | Male (N=8) | Female (N=10) |
| Trunk Flexion, kg | | | | |
| Pre | 4.33 ± 1.54 | 3.68 ± 1.13 | 5.60 ± 0.88 | 5.59 ± 2.15 |
| Post | 4.85 ± 1.50 [c] | 6.10 ± 1.93 [c] | 5.64 ± 1.31 [c] | 6.77 ± 1.93 [c] |
| Trunk Extension, kg | | | | |
| Pre | 6.91 ± 1.18 | 7.32 ± 2.09 | 8.74 ± 1.70 | 8.24 ± 1.84 |
| Post | 8.03 ± 2.85 [c] | 8.97 ± 1.04 [c] | 8.62 ± 2.38 [c] | 8.96 ± 2.50 [c] |
| Trunk rotation (D), kg | | | | |
| Pre | 4.29 ± 1.14 | 4.17 ± 1.14 | 5.12 ± 0.47 | 4.70 ± 1.03 |
| Post | 5.79 ± 1.14 [c] | 6.43 ± 1.43 [c] | 5.19 ± 1.17 [c] | 5.83 ± 1.39 [c] |
| Trunk rotation (ND), kg | | | | |
| Pre | 4.58 ± 0.91 | 3.81 ± 1.29 | 5.26 ± 1.50 | 4.89 ±1.43 |
| Post | 4.48 ± 1.25 [c] | 6.71 ± 1.24 [c] | 6.35 ± 1.21 [c] | 5.71 ± 1.41 [c] |

D: dominant, ND: non-dominant

[c] significant difference between pre and post-test

#### 4.4.1.5 Dominant gluteal extension strength

The difference in pre-test measurement of dominant gluteal extension strength was being analysed with an independent-samples t-test as shown in Table 4.4. The difference in strength between males in control group (M = 7.14, SD = 0.72) and males in intervention group (M = 6.38, SD = 2.36; t (5.709) = 0.756, p = 0.480, two-tailed) was measured and no significant difference was found between these two groups. There was no significant difference in the dominant gluteal extension strength between males in control group and females in control group (M = 8.03, SD = 1.55; t (16) = -1.498, p =0.154. two-tailed) as well as the strength between males in intervention group and females in intervention group (M = 6.88, SD = 1.94; t (16) = -0.477, p = 0.64, two-tailed). The result of independent-samples t-test also showed that no significant difference was found in the strength between females in control group and females in intervention group (t (20) = -0.477, p = 0.64). In short, there was no significant difference in pre-test measurement of dominant gluteal extension strength between all groups.

The post-test measurement of dominant gluteal extension strength was taken after the completion of 4-weeks intervention and the difference between groups was analysed using an independent-samples t-test (Table 4.4). The difference in strength between males in control group (M = 10.11, SD = 2.00) and males in intervention group (M = 10.04, SD = 1.84; t (12) = 0.068, p = 0.947, two-tailed) was being analysed and no significant difference was found between these two groups. Similar result was obtained for the dominant gluteal extension strength between males in control group and females in control group (M = 10.19, SD = 2.28; t (16) = -0.075, p =0.941, two-tailed) as well as the strength between females in control group and females in intervention group (M = 10.01, p = 2.01; t (20) = 0.201, p = 0.843, two-tailed). The independent-samples t-test also revealed that there was no significant difference in dominant gluteal extension strength between males in intervention group and females in intervention group (t (16) = 0.036, p = 0.972, two-tailed). Thus, it is clear that no significant difference was found in the post-test measurement of dominant gluteal extension strength between all groups.

The difference in dominant gluteal extension strength during the pre-test and post-test period was analysed using a paired-samples t-test to identify the impact of two different gluteal strengthening programs on the participants' dominant gluteal extension strength. The strength of males in control group increases from the baseline (M = 7.14 SD = 0.72) to post-intervention (M = 10.11, SD = 2.00), t (7) = -3.463, p = 0.011 (two-tailed) whereas the strength for males in intervention group increases from the baseline (M = 6.38, SD = 2.36) to post-intervention (M = 10.04, SD = 1.84), t (5) = -3.155, p = 0.025. Females in control group also showed an increase in dominant gluteal extension strength from baseline (M = 8.03, SD = 1.55) to post-intervention (M = 10.19, SD = 2.28), t (9) = -2.954, p = 0.016, while the strength for females in intervention group also increases from baseline (M = 6.88, SD = 1.94) to post-intervention (M = 10.01, SD = 2.01), t (11) = -5.388, p < 0.001. Hence, all groups displayed a statistically significant increase in the dominant gluteal extension strength from the baseline to post-intervention period.

#### 4.4.1.6 Non-dominant gluteal extension strength

Next, the difference in the pre-test measurement of gluteal muscle strength was compared between groups besides the trunk strength (Table 4.4). An independent-samples t-test was applied to compare the difference of the non-dominant gluteal extension strength between males in control group (M = 7.7, SD = 1.142) and males in intervention group (M = 6.07, SD = 1.63; t (12) = 2.209, p = 0.057, two-tailed) and the result showed that no significant difference was found between these two group. There was also no significant difference in the non-dominant gluteal extension strength between males in control group and females in control group (M = 7.63, SD = 1.71; t (16) = 0.093, p = 0.917. two-tailed) as well as the strength between males in intervention group and females in intervention group (M = 6.46, SD = 1.89; t (16) = -0.431, p = 0.672, two-tailed). The result of independent-samples t-test also showed that there was no significant difference in the non-dominant gluteal extension strength for females in control group and females in intervention group (t (20) = 1.500, p = 0.149, two-tailed). Hence, no significant difference was found in the pre-test measurement of non-dominant gluteal extension strength between all groups.

The difference in non-dominant gluteal extension strength after intervention was analysed using an independent-samples t-test. The non-dominant gluteal extension strength between males in control group (M = 9.61, SD = 1.40) and males in intervention group (M = 9.14, SD = 0.98; t (12) = 0.701, p = 0.497, two-tailed) was being compared and the result showed that no significant difference was found between these two groups. There was also no significant difference in post-test of measurement of non-dominant gluteal extension strength between males in control group and females in control group

(M = 10.20, SD = 2.19; t (16) = -0.660, p =0.519, two-tailed) as well as the strength between females in control group and females in intervention group (M = 8.93, SD = 1.86; t (20) = 1.474, p = 0.156, two-tailed). The independent-samples t-test also showed that there was no significant difference in the non-dominant gluteal extension strength between males in intervention group and females in intervention group (t (16) = 0.257, p = 0.800, two-tailed). As a result, all groups of participants did not have a significant difference in the post-test measurement of their non-dominant gluteal extension strength.

A paired-samples t-test was conducted to evaluate the impact of the two different gluteal strengthening programs on the participants' non-dominant gluteal extension strength before and after the intervention. Strength of males in control group increases from the baseline (M = 7.70, SD = 1.14) to post-intervention (M = 9.61, SD = 1.40), t (7) = -3.628, p = 0.008 (two-tailed) whereas the strength for males in intervention group increases from the baseline (M = 6.07, SD = 1.63) to post-intervention (M = 9.14, SD = 0.98), t (5) = -4.527, p = 0.006 (two-tailed). Females in control group showed a significant increase in non-dominant gluteal extension strength from baseline (M = 7.63, SD = 1.71) to post-intervention (M = 10.20, SD = 2.19), t (9) = -2.949, p = 0.016, while the strength for females in intervention group also increases from baseline (M = 6.46, SD = 1.90) to post-intervention (M = 8.93, SD = 1.86), t (11) = -3.968, p = 0.002 (two-tailed). In fact, there was a statistically significant increase in non-dominant gluteal extension strength in all groups.

The difference between dominant and non-dominant gluteal extension strength was analysed using a paired-samples t-test at pre-test and post-test period. The results of pre-test showed there was no significant difference between dominant (M = 7.17, SD = 1.74) and non-dominant glute (M = 7.00, SD = 1.73; t (35) = -0.814, p = 0.421). For post-test result, there was also no significant difference observed in dominant (M = 10.09, SD = 1.97) and non-dominant glute (M = 9.47, SD = 1.77; t (35) = -2.373, p = 0.053). Hence, no significant difference in the dominant and non-dominant gluteal extension strength observed for all groups during pre-test and post-test.

#### 4.4.1.7 Dominant gluteal abduction strength

The differences of the pre-test of dominant gluteal abduction strength between males in control group (M = 6.62, SD = 0.857) and males in intervention group (M = 5.95, SD = 1.02; t (12) = 1.335, p = 0.207. two-tailed) was determined using an independent-samples t-test. The result presented in Table 4.4 showed that there was no significant difference in dominant gluteal abduction strength between both groups. There was also no significant difference in the dominant gluteal abduction strength between males in control group and females in control group (M = 7.21, SD = 0.92; t (16) = -1.388, p = 0.184. two-tailed) as well as the strength between males in intervention group and females in intervention group (M = 5.73, SD = 1.62; t (16) = 0.309, p = 0.762, two-tailed). Besides, no significant difference was detected in the dominant gluteal abduction strength between females in control group and females in intervention group (t (20) = 0.191, p = 0.059, two-tailed). Therefore, no significant difference was found in the dominant gluteal abduction strength between all groups during the pre-test measurement.

The post-test measurement of dominant gluteal abduction strength was carried out after the intervention and the difference between groups was analysed using an independent-samples t-test (Table 4.4). The results showed that there was no significant difference found between males in control group (M = 8.97, SD = 1.10) and males in intervention group (M = 9.89, SD = 0.78; t (12) = -1.739, p = 0.108, two-tailed). No significant difference in dominant gluteal abduction strength was also detected between males in control group and females in control group (M = 8.63, SD = 1.49; t (16) = 0.545, p =0.593, two-tailed) as well as the strength between females in control group and females in intervention group (M = 8.55, p = 2.20; t (20) = 0.100, p = 0.921, two-tailed). A similar result has been found between males in intervention group and females in intervention group (t (16) = 1.433, p = 0.171, two-tailed).  In short, there was no significant difference found in the post-test measurement of dominant gluteal abduction strength between all groups.

A paired-samples t-test was conducted to evaluate the impact of the two different gluteal strengthening programs on the participants' dominant gluteal abduction strength. Strength of males in control group increases from the baseline (M = 6.61, SD = 0.857) to post-intervention (M = 9.86, SD = 2.21), t (7) = -4.093, p = 0.005 (two-tailed) whereas the strength for males in intervention group increases from the baseline (M = 5.95, SD = 1.02) to post-intervention (M = 9.76, SD = 1.08), t (5) = -18.792, p < 0.001(two-tailed). Females in control group showed an increase in dominant gluteal abduction strength from baseline (M = 7.21, SD = 0.92) to post-intervention (M = 8.15, SD = 0.89), t (9) = -6.705, p < 0.001 (two-tailed) while the strength for females in intervention group also improved from baseline (M = 5.73, SD = 1.62) to post-intervention (M = 9.36, SD = 2.43), t (11) = -6.631, p < 0.001 (two-tailed). Hence, all the groups exhibited a sharped increase in the dominant gluteal abduction strength after intervention.

#### 4.4.1.8 Non-dominant gluteal abduction strength

For the pre-test of non-dominant gluteal abduction strength, there was no significant difference between males in control group (M = 6.63, SD = 1.31) and males in intervention group (M = 6.01, SD = 1.83; t (12) = 0.737, p = 0.475. two-tailed) based on the results of the independent-samples t-test (Table 4.4). The non-dominant gluteal abduction strength between males in control group and females in control group (M = 7.12, SD = 1.64; t (16) = -0.688, p =0.502. two-tailed) were being compared and the result showed that no significant difference was detected between these two groups. There was also no significant difference in pre-test of non-dominant gluteal abduction strength for males in intervention group and females in intervention group (M = 5.79, SD = 1.83; t (20) = 0.236, p = 0.816, two-tailed) as well as the strength between females in control group (M = 7.12, SD = 1.64) and females in intervention group (M = 5.79, SD = 1.83; t (16) = 1.768, p = 0.092, two-tailed). Thus, no significant difference in pre-test of non-dominant gluteal abduction strength was observed between all groups.

The difference in non-dominant gluteal abduction strength after intervention was analysed using an independent-samples t-test. The result showed that there was no significant difference in the strength between males in control group (M = 8.97, SD = 1.10) and males in intervention group (M =

9.89, SD = 0.78; t (12) = -1.739, p = 0.108, two-tailed). The test also revealed that the non-dominant gluteal abduction strength between males in control group and females in control group (M = 8.63, SD = 1.49; t (16) = 0.545, p =0.593, two-tailed) was not significantly different from each other. There was also no significant difference found in the non-dominant gluteal abduction strength between females in control group and females in intervention group (M = 8.55, p = 2.20; t (20) = 0.100, p = 0.921, two-tailed) as well as the strength between males in intervention group and females in intervention group (t (16) = 1.433, p = 0.171, two-tailed). Therefore, it can be concluded that no significant difference in non-dominant gluteal abduction strength was found between all groups during the post-test.

A paired-samples t-test was applied to evaluate the impact of two different gluteal strengthening programs on the participants' non-dominant gluteal abduction strength. The strength of males in control group increases from baseline (M = 6.63 SD = 1.31) to post-intervention (M = 8.97, SD = 1.10), t (7) = -4.65, p = 0.002 (two-tailed) whereas the strength for males in intervention group also increases from the baseline (M = 6.01, SD = 1.83) to post-intervention (M = 9.89, SD = 0.78), t (5) = -4.935, p = 0.004. Females in control group demonstrated an increase in the non-dominant gluteal abduction strength from baseline (M = 7.12, SD = 1.64) to post-intervention (M = 8.63, SD = 1.49), t (9) = -6.421, p < 0.001 while the strength for females in intervention group also improved from baseline (M = 5.79, SD = 1.83) to post-intervention (M = 8.55, SD = 2.20), t (11) = -4.53, p < 0.001. Hence, a statistically significant increase in non-dominant gluteal abduction strength was observed in all groups from the baseline to the post-intervention period.

The difference between dominant and non-dominant gluteal abduction strength was analysed using a paired-samples t-test at pre-test and post-test period. The results of pre-test showed there was no significant difference between dominant (M = 6.37, SD = 1.31) and non-dominant glute (M = 6.38, SD = 1.70; t (35) = 0.039, p = 0.969). For post-test result, there was also no significant difference observed in dominant (M = 9.19, SD = 1.93) and non-dominant glute (M = 8.80, SD = 1.80; t (35) = -1.406, p = 0.168). Hence, no significant difference between the dominant and non-dominant gluteal abduction strength was observed for all groups during pre-test and post-test.

**Table 4.4: Strength of gluteal muscles**

| | Intervention | | Control | |
|---|---|---|---|---|
| | Male (N=6) | Female (N=12) | Male (N=8) | Female (N=10) |
| Gluteal extension (D), kg | | | | |
| Pre | 6.38 ± 2.36 | 6.88 ± 1.94 | 7.14 ± 0.72 | 8.03 ± 1.55 |
| Post | 10.01 ± 2.01 [c] | 10.04 ± 1.84 [c] | 10.11 ± 2.00 [c] | 10.19 ± 2.28 [c] |
| Gluteal extension (ND), kg | | | | |
| Pre | 6.07 ± 1.63 | 6.46 ± 1.89 | 7.70 ± 1.14 | 7.63 ± 1.71 |
| Post | 8.93 ± 1.86 [c] | 9.14 ± 0.98 [c] | 9.61 ± 1.40 [c] | 10.20 ± 2.19 [c] |
| Gluteal abduction (D), kg | | | | |
| Pre | 5.95 ± 1.02 | 5.73 ± 1.62 | 6.62 ± 0.86 | 7.21 ± 0.92 |
| Post | 9.36 ± 2.43 [c] | 9.76 ± 1.08 [c] | 9.86 ± 2.21 [c] | 8.10 ± 0.95 [c] |
| Gluteal abduction (ND), kg | | | | |
| Pre | 6.01 ± 1.83 | 5.79 ± 1.83 | 6.63 ± 1.31 | 7.12 ± 1.64 |
| Post | 8.28 ± 2.53 [c] | 9.89 ± 0.78 [c] | 8.97 ± 1.10 [c] | 8.63 ± 1.49 [c] |

D: dominant, ND: non-dominant

[c] significant difference between pre and post-test

### 4.4.2 Visual Analogue Scale (VAS)

Visual Analogue scale (VAS) is the second outcome measure used in this study to measure the pain intensity level among the participants with chronic non-specific LBP at two different timelines which are the pre-test and post-test period. An independent-samples t-test was applied to determine the difference in the pain intensity level between all groups during the pre-test and post-test period as shown in Table 4.5. Then, the difference in pain intensity level in pre-test and post-test period was compared and analysed using a paired-samples T-test.

An independent-samples t-test was used to compare the pre-test measurement of VAS score between groups and the results were presented in Table 4.5. The finding revealed that no significant difference was found in the VAS score between males in control group ($M = 4.13$, $SD = 1.36$) and males in intervention group ($M = 4.17$, $SD = 0.98$; $t(12) = -0.064$, $p = 0.950$. two-tailed). There was also no significant difference in VAS score between males in control group and females in control group ($M = 5.00$, $SD = 1.15$; $t(16) = -1.479$, $p = 0.158$. two-tailed) which the result is similar to the VAS score between females in control group and females in intervention group ($M = 5.17$, $SD = 1.34$; $t(20) = -0.309$, $p = 0.760$, two-tailed). The independent-samples t-test also revealed no significant difference was found in VAS score between males in intervention group and females in intervention group ($M = 5.17$, $SD = 1.34$; $t(16) = -1.616$, $p = 0.126$. two-tailed). As a result, there was no significant difference detected for the pre-test measurement of VAS score between all groups.

After the completion of 4-weeks intervention, the participants were asked to rate their pain level again on VAS. An independent-samples t-test was applied to compare the post-VAS score between males in control group ($M = 1.74$, $SD = 1.67$) and males in intervention group ($M = 1.83$, $SD = 0.75$; $t(12) = -0.127$, $p = 0.901$, two-tailed). There was no significant difference in post-VAS score between these two groups. The same test is used to compare the post-VAS score for males in control group and females in control group ($M = 1.70$, $SD = 1.77$; $t(16) = 0.049$, $p = 0.962$. two-tailed) but no significant relationship between these two groups. There was also no significant difference in post-VAS score between females in control group and females in intervention group ($M = 1.92$, $SD = 1.31$; $t(20) = -0.330$, $p = 0.745$, two-tailed) as well as the post-VAS score between males in intervention group and females in intervention group ($t(16) = -0.143$, $p = 0.888$. two-tailed). Hence, no significant difference was found in the post-test measurement of VAS score between all groups.

The VAS score before and after the intervention was being compared and analysed with a paired-samples t-test to evaluate the effect of two different gluteal strengthening programs on the pain score. The result showed that the VAS score of males in control group decreases from baseline ($M = 4.13$, $SD = 1.36$) to post-intervention ($M = 1.74$, $SD = 1.67$), $t(7) = 4.44$, $p = 0.003$ (two-tailed) whereas the VAS score for males in intervention group decreases from the baseline ($M = 4.17$, $SD = 0.98$) to post-intervention ($M = 1.83$, $SD = 0.75$), $t(5) = 6.128$, $p < 0.001$ (two-tailed). Females in control group showed a significant reduction in VAS score from baseline ($M = 5.00$, $SD = 1.15$) to post-intervention ($M = 1.70$. $SD = 1.77$), $t(9) = 7.00$, $p < 0.001$ (two-tailed) which is similar to the females in intervention group that showed a reduction in VAS score from baseline (M = 5.17, SD = 1.34) to post-intervention (M = 1.92, SD = 1.31), t (11) = 10.668, p < 0.001 (two-tailed). Thus, it showed there was a statistically significant decrease in VAS scores between all groups following intervention.

**Table 4.5: VAS score for LBP intensity**

| | Intervention | | Control | |
|---|---|---|---|---|
| | Male (N=6) | Female (N=12) | Male (N=8) | Female (N=10) |
| Pain (VAS) | | | | |
| Pre | 4.00 ± 1.26 | 5.17 ± 1.34 | 4.13 ± 1.36 | 5.09 ± 1.15 |
| Post | 1.83 ± 0.75 [c] | 1.92 ± 1.31 [c] | 2.25 ± 2.25 [c] | 1.15 ± 1.77 [c] |

VAS: Visual Analogue Scale

[c] significant difference between pre and post-test

### 4.4.3 Oswestry Disability Index (ODI)

The next outcome measure was ODI that were used to measure the functional disability level of participants caused by LBP. The difference in ODI score between all groups were measured with an independent-samples t-test at two timelines which were during the pre-test and post-test period as shown in Table 4.6. Then, a paired-samples t-test was used to evaluate the difference in ODI score in the pre-test and post-test period.

#### 4.4.3.1 ODI score

The difference in ODI score between groups was being compared with an independent-samples t-test and the finding was displayed in Table 4.6. Firstly, the result showed that there was no significant difference in the ODI score between males in control group (M = 4.25, SD = 2.49) and males in intervention group (M = 5.33, SD = 3.78), t (12) = -0.648, p =0.529 (two-tailed). The difference between males in control group and females in control group (M = 4.56, SD = 3.30), t (16) = -0.217, p = 0.831 (two-tailed) was being compared and the finding revealed that no significant difference was found between them. There was also no significant difference in ODI score between females in control group and females in intervention group (M = 5.08, SD = 2.31), t (20) = -0.439, p = 0.665 (two-tailed) as well as the ODI score between males in intervention group and females in intervention group (t (16) = 0.175, p = 0.863, two-tailed). As a result, there was no significant difference in the pre-test of ODI score between all groups.

After the completion of 4-weeks intervention, the difference in ODI score was measured again with the independent-samples t-test. It showed that no significant difference was found between males in control group (M = 2.25, SD = 3.14) and males in intervention group (M = 1.50, SD = 1.37; t (12) = 0.504, p = 0.623. two-tailed). The post-ODI score for males in control group and females in control group (M = 1.22, SD = 1.03; t (16) = 0.908, p = 0.377. two-tailed) was being compared and the result showed that there was no significant difference between these two groups. There was also no significant difference in the post-ODI score between males in intervention group and females in intervention group (M = 2.50, SD = 2.61; t (15.848) = -1.063, p = 0.304, two-tailed) as well as the score between females in control group and females in intervention group (t (14.861) = -1.556, p = 0.141).

A paired-samples t-test was conducted to evaluate the impact of the two different gluteal strengthening programs on the participants' ODI score. The ODI score of males in control group decreases from the baseline (M = 4.25, SD = 2.49) to post-intervention (M = 2.25, SD = 3.41), t (7) = 3.06, p = 0.018 (two-tailed) which the result was similar for the score among males in intervention group that decreases from the baseline (M = 5.33, SD = 3.78) to post-intervention (M = 1.50, SD = 1.38), t (5) = 3.781, p = 0.013 (two-tailed). Females in control group showed a reduction in ODI score from baseline (M = 4.56, SD = 3.30) to post-intervention (M = 1.22. SD = 1.03), t (9) = 2.753, p = 0.022 (two-tailed) while the ODI score for females in intervention group also decreases from baseline (M = 5.08, SD = 2.31) to post-intervention (M = 2.50, SD = 2.61), t (11) = 2.555, p = 0.027 (two-tailed). Hence, there was a statistically significant decrease in ODI scores between all groups.

#### 4.4.3.2 ODI percentage score (%)

The ODI score with a total score of 50 was converted into percentage score to be compared between groups. The independent-samples t-test showed that the pre-ODI percentage score between males in control group (M = 8.50, SD = 4.99) and males in intervention group (M = 10.67, SD = 7.55); t (12) = -0.648, p = 0.529 (two tailed) was not significantly different from each other. As presented in Table 4.6, the same result was obtained in the percentage score between males in control group and females in control group (M = 9.11, SD = 6.61), t (16) = -0.216, p = 0.831 (two-tailed) as well as the score between females in control group and females in intervention group (M = 10.17, SD = 4.63), t (20) = -0.440, p = 0.665 (two-tailed). There was also no significant difference in percentage score of ODI between males in intervention group and females in intervention group (t (16) = 0.175, p = 0.863, two-tailed). As a result, there was no significant difference found in the pre-ODI percentage score between all groups.

For the post-ODI percentage score, the independent-samples t-test showed that there was no significant difference found between males in control group (M = 4.50, SD = 6.82) and males in intervention group (M = 3.00, SD = 2.76; t (12) = 0.504, p = 0.623. two-tailed). The post-ODI percentage score for males in control group and females in control group (M = 2.44, SD = 2.06; t (8.025) = 0.823, p = 0.434. two-tailed) was being compared and the result showed that no significant difference was detected between these groups. No significant difference also found between the males in intervention group and females in intervention group (M = 4.50, SD = 4.76; t (16) = -0.708, p = 0.489, two-tailed) as well as the score between females in control group and females in intervention group (t (15.547) = -1.352, p = 0.196, two-tailed). In short, no significant difference was detected for the post-ODI percentage score between all groups.

A paired-samples t-test was applied to evaluate the impact of two different gluteal strengthening programs on the participants' functional disability level based on ODI. The ODI percentage score of males in control group decreases from the baseline (M = 8.50, SD = 4.99) to post-intervention (M = 4.50, SD = 6.82), t (7) = 3.055, p = 0.018 (two-tailed) whereas the ODI percentage score for males in intervention group decreases from the baseline (M = 10.67, SD = 7.55) to post-intervention (M = 3.00, SD = 2.76), t (5) = 3.781, p = 0.013 (two-tailed). Females in control group showed a reduction in ODI percentage score from baseline (M = 9.11, SD = 6.61) to post-intervention (M = 2.44 SD = 2.06), t (9) = 2.753, p = 0.022 (two-tailed), similar to score of females in intervention group which is also decreases from baseline (M = 10.17, SD = 4.63) to post-intervention (M = 4.50, SD = 4.76), t (11) = 3.027, p = 0.012 (two-tailed). Hence, there was a statistically significant decrease in ODI percentage score between all groups.

**Table 4.6: ODI score for LBP related disability indexes**

| | Intervention | | Control | |
|---|---|---|---|---|
| | Male (N=6) | Female (N=12) | Male (N=8) | Female (N=10) |
| Disability (ODI), score | | | | |
| Pre | 5.33 ± 3.78 | 5.08 ± 2.31 | 4.25 ± 2.49 | 4.56 ± 3.30 |
| Post | 1.50 ± 1.38 [c] | 2.50 ± 2.61 [c] | 2.25 ± 3.41 [c] | 1.22 ± 1.03 [c] |
| Disability (ODI), % | | | | |
| Pre | 10.67 ± 7.55 | 10.17 ± 4.63 | 8.50 ± 4.99 | 9.11 ± 6.61 |
| Post | 3.00 ± 2.76 [c] | 4.50 ± 4.76 [c] | 4.50 ± 6.82 [c] | 2.44 ± 2.06 [c] |

ODI: Oswestry Disability Index

[c] difference between pre and post-test

### 4.4.4 Y-balance test score

This subsection will present on the last outcome measure of this study which is the Y-balance test score. The composite score of Y-balance test was divided into absolute and normalized composite score and the difference in scores between groups was analysed using an independent-samples t-test. A paired-samples t-test was used to compare the difference in composite score at two different timelines which are during the pre-test and post-test period. The composite score of dominant leg and non-dominant leg in Y-balance test was recorded and compared using the same test. The absolute and normalized composite score between intervention and control group was presented in Table 4.7 whereas the difference in both composite score between sex was displayed in Table 4.8.

#### 4.4.4.1 Absolute composite score of dominant leg

An independent-samples t-test was used to compare the pre-test measurement of absolute composite score of dominant leg between groups and the result was presented in Table 4.7. The results showed that there was no significant difference between males in control group (M = 83.22, SD = 5.97) and males in intervention group (M = 79.31, SD = 10.39); t (12) = 0.894, p = 0.389 (two-tailed). The difference in absolute composite score of dominant leg between males in control group and females in control group (M = 86.40, SD = 12.51), t (13.455) = -0.707, p = 0.491 (two-tailed) was being compared and the result showed that no significant difference was found between them. No significant difference was also detected between females in control group and females in intervention group (M = 77.95, SD = 11.65), t (20) = 1.639, p = 0.117 (two-railed) as well as the score between males in intervention group and females in intervention group (t (16) = 0.242, p = 0.812, two-tailed). Therefore, no significant difference in the absolute composite score of dominant leg was found between all groups during the pre-test measurement.

The post-test measurement of absolute composite score of dominant leg were also taken and the difference between groups was analysed with an independent-samples t-test (Table 4.7). There was no significant difference in absolute composite score of dominant leg between males in control group (M = 88.72, SD = 8.21) and males in intervention group (M = 88.27, SD = 6.93; t (12) = 0.108, p = 0.916, two-tailed). The same result was obtained in the score between males in control group and females in control group (M = 96.88, SD = 5.26; t (16) = -2.566, p =0.051, two-tailed) as well as the score between females in control group and females in intervention group (M = 84.20, p = 9.82; t (20) = 3.661, p = 0.052, two-tailed). The independent-samples t-test also showed that there was no significant difference found in the absolute composite score of dominant leg between males in intervention group and females in intervention group (t (16) = 0.901, p = 0.381, two-tailed). As a result, the absolute composite score of dominant leg between all groups was not significantly different from each other during the post-test measurement.

A paired-samples t-test was used to evaluate the impact of the two different gluteal strengthening programs on the participants' absolute composite score of dominant leg. The absolute composite score of dominant leg of males in control group increases from the baseline (M = 83.22, SD = 5.97) to post-intervention (M = 88.72, SD = 8.21), t (7) = -1.904, p = 0.049 (two-tailed) whereas the absolute composite score of dominant leg for males in intervention group also increases from baseline (M = 79.31, SD = 10.39) to post-intervention (M = 88.27, SD = 6.93), t (5) = -2.753, p = 0.04 (two-tailed). Females in control group showed a marked increase in the absolute composite score of dominant leg from baseline (M = 86.42, SD = 12.48) to post-intervention (M = 96.88, SD = 5.26), t (9) = -2.318, p = 0.046 (two-tailed), similar to the score of females in intervention group which is also increases from baseline (M = 77.95, SD = 11.65) to post-intervention (M = 84.20, SD = 9.82), t (11) = -5.060, p < 0.001 (two-tailed). Based on the finding, there was a statistically significant improvement in the absolute composite score of dominant leg for all groups after the intervention.

#### 4.4.4.2 Absolute composite score of non-dominant leg

Besides that, the difference in absolute composite score of non-dominant leg was also compared during the pre-test measurement (Table 4.7). The difference in absolute composite score of non-dominant leg between groups was compared with an independent-samples t-test. The results showed that there was no significant difference between males in control group (M = 84.09, SD = 6.38) and males in intervention group (M = 79.74, SD = 9.45); t (12) = 1.032, p = 0.322 (two-tailed). The difference in absolute composite score of non-dominant leg between males in control group and females in control group (M = 85.02, SD = 12.19), t (14.095) = -0.208, p = 0.838 (two-tailed) was being compared and the result showed that no significant difference was found between them. No significant difference was detected between females in control group and females in intervention group (M = 79.74, SD = 9.94), t (20) = 1.119, p = 0.276 (two-tailed) as well as the score between males in intervention group and females in intervention group (t (16) = -0.001, p = 0.999, two-tailed). Hence, there was no significant difference in the absolute composite score of non-dominant leg during pre-test measurement between all groups.

For the post-test result of the absolute composite score of non-dominant leg, the finding of independent-samples t-test showed that no significant difference was found between males in control group (M = 91.20, SD = 7.02) and males in intervention group (M = 88.18, SD = 9.43; t (12) = 0.689, p = 0.504. two-tailed). The absolute composite score of non-dominant leg for males in control group and females in control group (M = 94.39, SD = 6.00; t (16) = -1.043, p = 0.313. two-tailed) was being compared and the result showed that no significant difference was detected between these groups which is similar to the result between males in intervention group and females in intervention group (M = 86.03, SD = 6.86; t (16) = 0.554, p = 0.587, two-tailed). There was also no significant difference in the absolute composite score of non-dominant leg between females in control group and females in intervention group (t (20) = 3.012, p = 0.057, two-tailed). Therefore, all groups showed no significant difference in the absolute composite score of non-dominant leg during pre-test measurement.

A paired-samples t-test was used to evaluate the impact of two different gluteal strengthening programs on the participants' absolute composite score of non-dominant leg. The absolute composite score of non-dominant leg for males in control group increases from baseline (M = 84.09, SD = 6.38) to post-intervention (M = 91.20, SD = 7.02), t (7) = -2.192, p = 0.046 (two-tailed) whereas the score for males in intervention group increases from baseline (M = 79.74, SD = 9.45) to post-intervention (M = 88.18, SD = 9.43), t (5) = -1.575, p = 0.018 (two-tailed). Females in control group showed a marked increase in the absolute composite score of non-dominant leg from baseline (M = 85.02, SD = 12.19) to post-intervention (M = 94.39, SD = 6.00), t (9) = -2.316, p = 0.046 (two-tailed), similar to the result for females in intervention group which is also increases from baseline (M = 79.74, SD = 9.94) to post-intervention (M = 86.03, SD = 6.86), t (11) = -4.858, p < 0.001 (two-tailed). Hence, there was a statistically significant improvement in the absolute composite score of non-dominant leg for all groups from the baseline to the post-test period.

#### 4.4.4.3 Normalized composite score of dominant leg

The normalized composite score of dominant leg was also calculated from the absolute composite score to complete the data analysis for Y-balance test (Table 4.7). The difference of the normalized composite score of dominant leg between groups was analysed with an independent-samples t-test before the intervention started. The results showed that there was no significant difference was found in the normalized composite score between males in control group (M = 90.39, SD = 13.75) and males in intervention group (M = 90.60, SD = 13.05); t (12) = -0.029, p = 0.977 (two-tailed) which was similar to the score between males in control group and females in control group (M = 100.60, SD = 7.10), t (16) = -2.042, p = 0.058 (two-tailed). The difference in normalized composite score was measured between females in control group and females in intervention group (M = 92.35, SD = 12.66), t (20) = 1.831, p = 0.082 (two-tailed) but no significant difference was found between them which was similar to the difference in score between males in intervention group and females in intervention group (t (16) = -0.273, p = 0.788, two-tailed). Thus, it was cleared that no significant difference was found in the normalized composite score of dominant leg between all groups during the pre-test period.

The difference in normalized composite score of dominant leg after intervention period was analysed using an independent-samples t-test. The result showed that there was no significant difference found in score between males in control group (M = 97.39, SD = 7.44) and males in intervention group (M = 100.81, SD = 6.13; t (12) = -0.916, p = 0.378, two-tailed). The result of the independent-samples t-test showed that there was no significant difference found in the normalized composite score of dominant leg between males in intervention group and females in intervention group (M = 102.64, SD = 6.92; t (16) = -0.545, p = 0.593, two-tailed). Besides, no significant difference was found in the normalized composite score of dominant leg between males in control group and females in control group (M = 118.86, SD = 9.99; t (16) = -5.049, p = 0.051, two-tailed) as well as the score between females in control group and females in intervention group (t (20) = 4.488, p = 0.051, two-tailed). Hence, there was no significant difference in the normalized composite score of dominant leg between all groups during the post-test measurement.

A paired-samples t-test was conducted to evaluate the impact of two different gluteal strengthening programs on the participants' normalized composite score of dominant leg. The normalized composite score of dominant leg of males in control group increases from the baseline (M = 90.39, SD = 13.75) to post-intervention (M = 98.01, SD = 7.42), t (7) = -1.444, p = 0.019

(two-tailed) whereas the score for males in intervention group increases from the baseline (M = 90.60, SD = 13.05) to post-intervention (M = 100.81, SD = 6.13), t (5) = -2.162, p = 0.038 (two-tailed). Females in control group showed a marked increase in the normalized composite score of dominant leg from baseline (M = 100.60, SD = 7.10) to post-intervention (M = 118.86, SD = 9.99), t (9) = -4.217, p = 0.02 (two-tailed), similar to the score of females in intervention group which increases from baseline (M = 92.35, SD = 12.66) to post-intervention (M = 101.33, SD = 6.85), t (11) = -2.907, p = 0.014 (two-tailed). Therefore, the improvement in normalized composite of dominant leg was demonstrated by all groups following intervention.

#### 4.4.4.4 Normalized composite score of non-dominant leg

Other than that, an independent-samples t-test was used to compare the difference in the normalized composite score of non-dominant leg between groups during the pre-test measurement (Table 4.7). The results showed that there was no significant difference in the score between males in control group (M = 94.66, SD = 7.74) and males in intervention group (M = 90.89, SD = 10.68); t (12) = 0.767, p = 0.458 (two-tailed). There was also no significant difference found in normalized composite score of non-dominant leg between males in control group and females in control group (M = 101.04, SD = 11.65), t (16) = -1.328, p = 0.203 (two-tailed), similar to the difference in score between females in control group and females in intervention group (M = 95.46, SD = 11.58), t (20) = 1.121, p = 0.275 (two-tailed). No significant difference was detected in the score between males in intervention group and females in intervention group (t (16) = -0.808, p = 0.431), two-tailed. In short, there was no significant difference found in the normalized composite score of non-dominant leg between all groups during the pre-test.

The difference in normalized composite score of non-dominant leg after intervention was analysed using an independent-samples t-test which showed that no significant difference found between males in control group (M = 102.75, SD = 6.61) and males in intervention group (M = 100.62, SD = 10.00; t (12) = 0.481, p = 0.639, two-tailed). No significant difference also found in the normalized composite score between males in intervention group and females in intervention group (M = 103.24, SD = 5.74; t (16) = -0.714, p = 0.486, two-tailed). There was also no significant difference found in the post-test of normalized composite score of non-dominant leg between males in control group and females in control group (M = 110.88, SD = 7.73; t (16) = -2.362, p = 0.051, two-tailed) as well as the score between females in control group and females in intervention group (t (20) = 2.661, p = 0.150, two-tailed). Hence, no significant difference was found in the normalized composite score of non-dominant leg between all groups during post-test.

The impact of two different gluteal strengthening programs on the participants' normalized composite score of non-dominant leg was evaluated using a paired-samples t-test. The normalized composite score of non-dominant leg among males in control group increases from the baseline (M = 94.66, SD = 7.74) to post-intervention (M = 102.75, SD = 6.61), t (7) = -2.6, p = 0.035 (two-tailed) whereas the score for males in intervention group increases from the baseline (M = 90.89, SD = 10.68) to post-intervention (M = 100.62, SD = 10.00), t (5) = -4.146, p = 0.009 (two-tailed). Females in control group showed a marked increase in the normalized composite score of non-dominant leg from baseline (M = 101.04, SD = 11.65) to post-intervention (M = 101.04, SD = 11.65), t (9) = -2.273, p = 0.025 (two-tailed) while the score for females in intervention group also increases from baseline (M = 95.46, SD = 11.58) to post-intervention (M = 103.24, SD = 5.74), t (11) = -2.542, p = 0.027 (two-tailed). As a result, there was a statistically significant increase in the normalized composite score of non-dominant leg in all groups following exercises.

#### 4.4.4.5 Difference in absolute and normalized composite score between dominant and non-dominant leg

The difference between absolute composite score of dominant leg and non-dominant leg during the pre-test was being measured using a paired-samples t-test. Firstly, there was no significant difference in the absolute composite score between the dominant leg (M = 83.22, SD = 5.97) and non-dominant leg (M = 84.09, SD = 6.38); t (7) = -0.841, p = 0.428 (two-tailed) among the males in control group. No significant difference also found in absolute composite score between dominant leg (M = 79.31, SD = 10.39) and non-dominant leg (M = 79.74, SD = 9.45); t = -0.184, p = 0.861 (two-tailed) among the males in intervention group as well as the dominant leg (M = 86.42, SD = 12.48) and non-dominant leg (M = 85.02, SD = 12.19); t = 1.365, p = 0.206 (two-tailed) among females in control group. The independent-samples t-test showed that no significant difference in the absolute composite score between dominant leg (M = 77.95, SD = 11.65) and non-dominant leg (M =

79.74, SD = 9.94); t = -1.413, p = 0.185 (two-tailed) among the females in intervention group. In short, there was no significant difference in the absolute composite score between the dominant and non-dominant leg during the pre-test measurement.

A paired-samples t-test was used to compare the difference in the absolute composite score between dominant and non-dominant leg during the post-test measurement. There was no significant difference in the score between the dominant leg (M = 88.72, SD = 8.21) and non-dominant leg (M = 91.20, SD = 7.02); t (7) = -1.558, p = 0.163 (two-tailed) among males in the control group. No significant difference was found between the dominant leg (M = 88.27, SD = 6.93) and non-dominant leg (M = 88.18, SD = 9.43); t = 0.048, p = 0.963 (two-tailed) among males in intervention group which was similar to the dominant leg (M = 96.88, SD = 5.26) and non-dominant leg (M = 94.39, SD = 6.00); t (9)= 1.676, p = 0.128 (two-tailed) among females in control group. There was also no significant difference in absolute composite score between the dominant leg (M = 84.20, SD = 9.82) and non-dominant leg (M = 86.03, SD = 6.86); t = -1.276, p = 0.228 (two-tailed) among the females in intervention group. In short, there was no significant difference in the absolute composite score between the dominant and non-dominant leg among all groups after the intervention.

In addition, the difference between normalized composite score of dominant leg and non-dominant leg during the pre-test was being measured using a paired-samples t-test. Firstly, there was no significant difference in the normalized composite score between the dominant leg (M = 90.39, SD = 13.75) and non-dominant leg (M = 94.66, SD = 7.74), t (7) = -0.962, p = 0.368 (two-tailed) of males in the control group which is similar with the result of dominant leg (M = 90.60, SD = 13.05) and non-dominant leg (M = 90.89, SD = 10.68); t (5)= 0.104, p = 0.922 (two-tailed) among males in the intervention group. There was no significant difference in the normalized composite score between the dominant leg (M = 100.60, SD = 7.10) and non-dominant leg (M = 101.04, SD = 11.65); t (9) = 0.130, p = 0.899 (two-tailed) among the females in control group as well as the score between dominant leg (M = 92.35, SD = 12.66) and non-dominant leg (M = 95.46, SD = 11.58); t (11) = 2.257, p = 0.051 (two-tailed) among the females in intervention group. In short, there was no significant difference in the normalized composite score between the dominant and non-dominant leg for all groups during the pre-test period.

The post-test measurement was taken and the difference between normalized composite score between the dominant and non-dominant leg was being measured using a paired-samples t-test. Firstly, there was no significant difference in the normalized composite score between the dominant leg (M = 98.01, SD = 7.42) and non-dominant leg (M = 102.75, SD = 6.61); t (7) = -1.542, p = 0.167 (two-tailed) among the males in control group. No significant difference was detected between the dominant leg (M = 100.81, SD = 6.13) and non-dominant leg (M = 100.62, SD = 10.00); t (5) = -0.086, p = 0.935 (two-tailed) among males in intervention group as well as the dominant leg (M = 118.86, SD = 9.99) and non-dominant leg (M = 110.88, SD = 7.73); t (9)= -3.018, p = 0.055 (two-tailed) among the females in control group. There was also no significant difference in normalized composite score between the dominant leg (M = 101.33, SD = 6.85) and non-dominant leg (M = 103.24, SD = 5.74); t (11) = 1.736, p = 0.110 (two-tailed) among the females in intervention group. In short, there was no significant difference in the normalized composite score between the dominant and non-dominant leg among all groups during the post-test measurement.

**Table 4.7: Balance score between control and intervention group**

| Balance and its derivatives | Side | | Intervention | | Control | |
|---|---|---|---|---|---|---|
| | | | Male (N=6) | Female (N=12) | Male (N=8) | Female (N=10) |
| Anterior Reach Distance, cm | D | Pre | 53.08 ± 5.77 | 49.60 ± 7.72 | 52.94 ± 3.77 | 54.24 ± 6.54 |
| | | Post | 56.97 ± 5.26 | 54.69 ± 6.05 | 57.15 ± 6.27 | 59.63 ± 5.13 |
| | ND | Pre | 50.64 ± 7.94 | 51.60 ± 6.37 | 53.33 ± 6.50 | 54.00 ± 5.99 |
| | | Post | 59.11 ± 5.82 | 55.58 ± 3.56 | 56.15 ± 8.26 | 58.70 ± 6.77 |
| Posteromedial Reach Distance, cm | D | Pre | 79.67 ± 13.68 | 74.04 ± 12.12 | 82.90 ± 13.29 | 82.78 ± 11.70 |
| | | Post | 89.78 ± 9.55 | 80.53 ± 11.15 | 92.90 ± 11.25 | 92.28 ± 8.01 |
| | ND | Pre | 81.50 ± 9.01 | 77.25 ± 12.71 | 84.92 ± 9.99 | 83.73 ± 11.67 |
| | | Post | 89.19 ± 10.86 | 82.45 ± 8.62 | 92.85 ± 9.90 | 89.20 ± 11.46 |
| Posterolateral Reach Distance, cm | D | Pre | 75.61 ± 10.76 | 71.81 ± 14.41 | 80.71 ± 14.87 | 80.35 ± 16.57 |
| | | Post | 85.69 ± 9.57 | 78.35 ± 12.16 | 91.83 ± 12.98 | 91.92 ± 8.42 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ND | Pre | 77.86 ± 14.47 | 71.31 ± 11.06 | 78.92 ± 13.97 | 76.08 ± 13.98 |
| | | Post | 84.00 ± 12.52 | 80.08 ± 10.16 | 93.15 ± 11.34 | 89.97 ± 7.07 |
| Absolute composite score, % | D | Pre | 79.74 ± 9.45 | 77.94 ± 12.15 | 82.92 ± 5.33 | 86.39 ± 12.51 |
| | | Post | 88.27 ± 6.94 [c] | 84.20 ± 9.82 [c] | 89. 05 ± 7.91 [c] | 96.89 ± 5.26 [c] |
| | ND | Pre | 79.64 ± 7.63 | 79.74 ± 10.25 | 84.09 ± 6.38 | 85.02 ± 12.19 |
| | | Post | 88.18 ± 9.43 [c] | 86.03 ± 6.86 [c] | 91.23 ± 7.10 [c] | 94.40 ± 6.00 [c] |
| Normalized Anterior Reach Distance, % | D | Pre | 60.53 ± 5.99 | 59.33 ± 7.93 | 61.30 ± 7.54 | 64.72 ± 7.56 |
| | | Post | 65.04 ± 4.18 | 66.92 ± 3.28 | 61.69 ± 3.41 | 71.64 ± 3.88 |
| | ND | Pre | 57.63 ± 8.19 | 62.10 ± 6.08 | 61.62 ± 4.17 | 64.53 ± 8.36 |
| | | Post | 67.29 ± 5.39 | 66.49 ± 2.38 | 64.31 ± 7.44 | 69.95 ± 7.43 |
| Normalized Posteromedial Reach Distance, % | D | Pre | 90.96 ± 15.72 | 88.57 ± 12.78 | 91.85 ± 14.59 | 89.65 ± 13.29 |
| | | Post | 102.30 ± 9.06 | 95.23 ± 12.53 | 102.05 ± 10.90 | 110.25 ± 7.16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ND | Pre | 92.89 ± 10.02 | 91.61 ± 12.32 | 97.38 ± 7.22 | 99.80 ± 13.45 |
| | | Post | 101.59 ± 11.51 | 96.40 ± 7.40 | 105.02 ± 9.67 | 95.30 ± 12.21 |
| Normalized Posterolateral Reach Distance, % | D | Pre | 86.33 ± 13.68 | 83.07 ± 12.42 | 91.12 ± 14.01 | 98.59 ± 12.26 |
| | | Post | 97.16 ± 7.83 | 89.63 ± 9.82 | 101.25 ± 103.77 | 108.89 ± 6.61 |
| | ND | Pre | 88.69 ± 16.11 | 85.38 ± 10.74 | 92.80 ± 9.79 | 90.72 ± 16.38 |
| | | Post | 95.33 ± 13.40 | 94.05 ± 9.35 | 103.77 ± 8.75 | 107.18 ± 6.78 |
| Normalized Composite score, % | D | Pre | 90.61 ± 13.05 | 92.35 ± 12.66 | 90.39 ± 13.75 | 100.60 ± 7.10 |
| | | Post | 100.81 ± 6.13 [c] | 101.33 ± 6.85 [c] | 98.01 ± 7.42 [c] | 118.86 ± 9.99 [c] |
| | ND | Pre | 90.89 ± 10.68 | 95.46 ± 11.58 | 94.66 ± 7.74 | 101.04 ± 11.65 |
| | | Post | 100.62 ± 10.00 [c] | 103.24 ± 5.74 [c] | 102.75 ± 6.61 [c] | 110.88 ± 7.73 [c] |

**Table 4.7: Balance score between control and intervention group (cont')**

D: dominant, ND: non-dominant

[c] significant difference between pre and post-test

#### 4.4.4.6 Difference in absolute and normalized composite score between sex

Then, the participants were categorized into male and female group to compare their Y-balance score according to their sex. The difference in the absolute composite score of dominant and non-dominant leg between male and female was being compared with an independent-samples t-test as shown in Table 4.8. During the pre-test, there was no significant difference in the absolute composite score of both dominant leg between male (M = 81.55, SD = 8.05) and female group (M = 81.80, SD = 12.51); t (33.98) = -0.073, p = 0.942 (two-tailed) which is similar to the result of non-dominant leg score between male (M = 82.22, SD = 7.83) and female group (M = 82.14, SD = 11.08); t (34) = 0.024, p = 0.981 (two-tailed). Hence, there was no significant difference during the pre-test measurement of absolute composite score between the male and female group regardless of dominant or non-dominant leg.

The difference in absolute composite score during the post-test measurement was also analysed with an independent-samples t-test (Table 4.8). There was no significant difference in the absolute composite score of dominant leg score between male (M = 88.52, SD = 7.41) and female group (M = 89.97, SD = 10.20); t (34) = -0.457, p = 0.651 (two-tailed) as well as the non-dominant leg score between male (M = 89.90, SD = 7.95) and female group (M = 89.83, SD = 7.63); t (34) = 0.027, p = 0.979 (two-tailed). In short, no significant difference was found in the absolute composite score between the male and female group during the post-test period regardless of dominant or non-dominant leg.

A paired-samples t-test was conducted to evaluate the impact of the two different gluteal strengthening programs on the absolute composite score of dominant and non-dominant leg between males and females. The absolute composite score of dominant leg in males increases from the baseline (M = 81.55, SD = 8.05) to post-intervention (M = 88.52, SD = 7.41), t (13) = -3.278, p = 0.006 (two-tailed) whereas the absolute composite score of non-dominant leg for males increases from the baseline (M = 82.22, SD = 7.83) to post-intervention (M = 89.90, SD = 7.95), t (13) = -2.714, p = 0.018. Females showed a marked increase in the absolute composite score of dominant leg from baseline (M = 81.80, SD = 12.51) to post-intervention (M = 89.97, SD = 10.20), t (21) = -3.802, p = 0.001 while the absolute composite score of non-dominant leg for females also increases from baseline (M = 82.14, SD = 11.08) to post-intervention (M = 89.83, SD = 7.63), t (21) = -3.953, p < 0.001. Hence, there was a significant difference between pre-test and post-test of the absolute composite score of dominant and non-dominant leg in males and females.

In addition, the normalized composite score was also being compared between sex to find out whether there is any difference between them. The pre-test results of independent-samples t-test revealed that no significant difference was found in the normalized composite score of the dominant leg between male (M = 90.48, SD = 12.93) and female (M = 96.10, SD = 11.10); t (34) = -1.388, p = 0.174 (two-tailed) as well as the non-dominant leg score between male (M = 93.04, SD = 8.94) and female (M = 98.00, SD = 11.68); t (34) = 1.351, p = 0.186 (two-tailed). As a result, there was no marked difference in the normalized composite score between male and female group during the pre-test measurement regardless of dominant or non-dominant leg score.

Then, the difference in normalized composite score during the post-test measurement was also analysed with an independent-samples t-test as illustrated in Table 4.8. There was no significant difference found in the normalized composite score of dominant leg score between male (M = 99.21, SD = 6.79) and female group (M = 109.30, SD = 12.13); t (33.61) = -3.192, p = 0.053 (two-tailed). Same result was found in the normalized composite score of non-dominant leg between male (M = 101.84, SD = 7.95) and female group (M = 106.72, SD = 7.62); t (34) = -1.842, p = 0.074 (two-tailed). In short, no significant difference was found in the normalized composite score of dominant leg and non-dominant during post-test period.

After that, a paired-samples t-test was conducted to evaluate the impact of the two different gluteal strengthening programs on the normalized composite score of dominant and non-dominant leg between males and females. The normalized composite score of dominant leg in males increases from the baseline (M = 90.48, SD = 12.93) to post-intervention (M = 99.21, SD = 6.79), t (13) = -2.483, p = 0.027 (two-tailed) whereas the normalized composite score of non-dominant leg for males increases from the baseline (M = 93.04, SD = 8.94) to post-intervention (M = 101.84, SD = 7.95), t (13) = -4.431, p < 0.001. Females showed a marked increase in the normalized composite score of dominant leg from baseline (M = 96.10, SD = 11.10) to post-intervention (M = 109.30, SD = 12.13), t (21) = -4.853, p < 0.001 while the normalized composite score of non-dominant leg for females also increases from baseline (M = 98.00, SD = 11.68) to post-intervention (M = 106.72, SD = 7.62), t (21) = -3.47, p = 0.002. Hence, there was a statistically significant improvement in the normalized composite score of dominant and non-dominant leg following intervention among both male and female groups.

**Table 4.8: Balance score between male and females**

| Balance and its derivatives | Side | | Sex | | |
|---|---|---|---|---|---|
| | | | All (N=36) | Males (N=14) | Females (N=22) |
| Anterior Reach Distance, cm | D | Pre | 52.05 ± 6.43 | 52.58 ± 4.99 | 51.71 ± 7.30 |
| | | Post | 56.99 ± 5.82 | 57.07 ± 5.64 | 56.94 ± 6.06 |
| | ND | Pre | 52.49 ± 6.33 | 52.18 ± 7.00 | 52.69 ± 6.02 |
| | | Post | 57.12 ± 6.07 | 57.42 ± 7.22 | 56.93 ± 5.39 |
| Posteromedial Reach Distance, cm | D | Pre | 79.37 ± 12.50 | 81.51± 13.03 | 78.02 ± 12.27 |
| | | Post | 88.08 ± 11.15 | 91.56 ± 10.29 | 85.87 ± 11.34 |
| | ND | Pre | 81.46 ± 11.09 | 83.45 ± 9.38 | 80.20 ± 12.10 |
| | | Post | 87.40 ± 10.48 | 91.29 ± 10.08 | 84.93 ± 10.18 |
| Posterolateral Reach Distance, cm | D | Pre | 76.79 ± 14.38 | 78.52 ± 13.05 | 75.69 ± 15.36 |
| | | Post | 86.34 ± 12.22 | 89.20 ± 11.66 | 84.52 ± 12.48 |
| | ND | Pre | 75.42 ± 12.84 | 78.46 ± 13.64 | 73.48 ± 12.22 |
| | | Post | 85.94 ± 11.04 | 89.23 ± 12.31 | 83.85 ± 9.88 |
| Composite score, % | D | Pre | 81.63 ± 10.79 | 81.37 ± 7.77 | 81.79 ± 12.52 |
| | | Post | 89.48 ± 9.07 [c] | 88.72 ± 7.23 [c] | 89.97 ± 10.20 [c] |
| | ND | Pre | 82.17 ± 9.82 | 82.22 ± 7.83 | 82.14 ± 11.08 |
| | | Post | 89.41 ± 7.55 [c] | 89.92 ± 7.99 [c] | 89.09 ± 7.43 [c] |
| Normalized Anterior Reach Distance, % | D | Pre | 61.47 ± 7.46 | 60.97 ± 6.67 | 61.78 ± 8.06 |
| | | Post | 66.75 ± 5.03 | 63.12 ± 4.00 | 69.06 ± 4.23 |
| | ND | Pre | 61.92 ± 6.91 | 59.91 ± 6.27 | 63.20 ± 7.13 |
| | | Post | 67.10 ± 5.95 | 65.59 ± 6.58 | 68.06 ± 5.45 |

| | | | | | |
|---|---|---|---|---|---|
| Normalized | D | Pre | 90.00 ± 13.28 | 91.47 ± 14.49 | 89.06 ± 12.71 |
| Posteromedial | | Post | 102.10 ± 11.54 | 102.16 ± 9.77 | 102.06 ± 12.76 |
| Reach | ND | Pre | 95.38 ± 11.46 | 95.46 ± 8.48 | 95.33 ± 13.21 |
| Distance, % | | Post | 98.88 ± 10.26 | 103.55 ± 9.72 | 95.90 ± 9.64 |
| Normalized | D | Pre | 89.71 ± 13.90 | 89.07 ± 13.55 | 90.12 ± 14.42 |
| Posterolateral | | Post | 98.82 ± 11.91 | 99.50 ± 10.66 | 98.39 ± 12.87 |
| Reach | ND | Pre | 89.06 ± 13.04 | 91.04 ± 12.48 | 87.81 ± 13.52 |
| Distance, % | | Post | 100.07 ± 10.65 | 100.15 ± 11.29 | 101.74 ± 10.14 |
| Normalized | D | Pre | 93.92 ± 11.99 | 90.48 ± 12.93 | 96.10 ± 11.10 |
| Composite | | Post | 105.37 ± 11.42 [c] | 99.21 ± 6.79 [c] | 109.30 ± 12.13 [c] |
| score, % | ND | Pre | 96.07 ± 10.84 | 93.04 ± 8.94 | 98.00 ± 11.68 |
| | | Post | 104.82 ± 8.01 [c] | 101.84 ± 7.95 [c] | 100.02 ± 10.50 [c] |

**Table 4.8: Balance score between males and females (cont')**

D: dominant, ND: non-dominant

[c] significant difference between pre and post-test

### 4.5 Hypothesis Testing

$H_0$: There is no significant difference between two gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic LBP.

$H_1$: There is a significant difference between two gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic LBP.

The pre-test and post-test measurement of the trunk and gluteal strength, pain, functional disability and balance were being analysed by a paired-samples t-test. The result revealed that there was a statistically significant difference ($p < 0.05$) in the mean score of trunk and gluteal muscle strength, VAS, ODI and Y-balance test score. Hence, the alternative hypothesis ($H_1$) was rejected whereas the null hypothesis ($H_0$) was accepted. This indicates that there is no significant difference between two gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic LBP.

# CHAPTER 5

# DISCUSSIONS

## 5.1 Chapter overview

This chapter discussed the important findings based on the result sections regarding the impact of different gluteal strengthening program on the trunk and muscle strength, pain, functional disability and balance among participants with chronic non-specific LBP.

## 5.2 Discussion

### 5.2.1 Demographic of population

The age of participants lied between 18 to 25 years old which fulfil the inclusion criteria of the research project. The height and weight of male participants in this study were significantly different from the female participants. The results showed that the height and weight of male participants were higher than female participants in both control and intervention groups due to the difference in sex chromosomes and sex hormones that regulate the body height and weight (Rodriguez, 2018). No significant difference in the BMI was detected between all groups of participants as their BMI level lies within the healthy weight range which is between 18.5 to 24.9 (*Assessing your weight*, 2022).

### 5.2.2 Effect of different gluteal strengthening program on muscle strength

#### 5.2.2.1 Effect of different gluteal strengthening program on trunk muscle strength

For trunk extension and flexion, there were a significant improvement on strength following exercise observed in intervention and control groups. However, there is no difference between control and intervention group. The improvement in trunk flexion and extension was similar with previous studies that concluded the combination of lumbar stability exercise and gluteal strengthening exercise improves the lumbar isometric flexion and extension strength (Jeong et al., 2015). The improvement in trunk extension and flexion strength may occur due to the impact of bird dog exercise and modified curl up exercise respectively under the McGill core stabilization program. Bird dog exercise improves care stability and emphasizes on the extensor movement but it only places a small amount of external load on the spine (Aly et al., 2017). On the other hand, modifies curl up exercise increases the trunk flexion strength because it targets the deep and superficial layer of anterior abdominal muscles that are responsible for the trunk flexion movement (Aly et al., 2017). This explains the improvement in the trunk extension and flexion strength after intervention. Hence, these exercises should be prescribed for LBP patients because most of them experience trunk muscles weakness (Jeong et al., 2015).

Besides that, the trunk rotation strength of dominant and non-dominant side was being assessed and a significant improvement was shown in both control and intervention groups after the intervention but no significant difference in strength was observed between these two groups. No comparison can be made because there is lack of study that explore the effect of core and gluteal strengthening exercise on trunk rotation strength. Side-bridge exercise under the McGill core stabilization program potentially increase trunk rotation strength because it activates the lateral oblique muscles which are the external obliques located on either side of body while applying minimal pressure on the spine (Horschig & Sonthana, 2018). These muscles contract contralaterally during trunk rotation together with the rectus abdominis and lumbar multifidus (Sugaya et al., 2016). Gluteal strengthening program also provides a stable base for the lumbar spine (Kim & Yim, 2020) and improves the lumbar spine mechanics (Kendall et al., 2015). Hence, gluteal strengthening exercise should be added to the traditional core stabilization exercise for LBP patients to regain their trunk muscle strength and postural stability.

To sum up, the NGSP has a same strengthening effect of trunk extension, flexion and rotation as the control group because both groups was given the same McGill core stabilization program. This program improves the core muscles strength and stiffness by introducing the 3 specific exercise targeted the back muscles, abdominal muscles and the lateral muscles of the trunk (Aly et al., 2017). Besides that, the improvement in trunk muscle strength in both groups also contributed by the gluteal strengthening program because lumbopelvic hip complex muscles dysfunction is the characteristic finding of LBP (Sadler et al., 2019). Previous study proposed that the addition of gluteal strengthening exercise to lumbar stabilization exercise results in a significant improvement in lumbar isometric strength when compared to lumbar stabilization exercise alone (Jeong et al., 2015). Hence, the trunk extensor, flexor and rotator strength increase following intervention but no difference was found between intervention and control group.

### 5.2.2.2 Effect of different gluteal strengthening program on gluteal muscle strength

For gluteal extension, there was a significant improvement on strength of both dominant and non-dominant leg after exercise observed in intervention and control group but there is no difference between intervention and control group. For control group, the improvement in gluteal extension strength was consistent with the research conducted by Fukuda et al. (2021). However, for the intervention group, comparison to other study could not be made because this is the first study to explore the effect of step up exercise on gluteus maximus strength. The improvement in gluteal extensor strength in the intervention group could be explained by the effect of step-up exercise under the NGSP. Step-up has the greatest activation of the gluteus maximus which is the primary gluteal extensor that is responsible to stretch the hip joint while keeping the pelvis in position during weight-bearing exercise (Reiman et al., 2012). Step-up exercise was done in a weight bearing position thus more demands were placed on the gluteal muscles and the activation of gluteal maximus becomes greater (Neto et al., 2020). Gluteus maximus also prevent excessive femur adduction and internal rotation during step-up (Neto et al., 2020). Furthermore, gluteus maximus and gluteus medius have to maintain the pelvis level when the exercise pattern exerts a greater movement demands by gluteal abduction and external rotation to limit the knee valgus (Reiman et al., 2012). This finding was supported by previous study that highlight the role of gluteus maximus which stabilize pelvis during trunk rotation or when the center of gravity is shifted. There is a need to strengthen gluteus maximus because it is more prone to fatigue among non-specific chronic LBP patient (Nadler et al., 2002). Therefore, NGSP is effective to improve the gluteal extension strength of both dominant and non-dominant leg and it is preferred over SGSP because it was easier to perform and lesser time is needed to complete all exercise.

Besides that, there was a significant improvement observed on the gluteal abduction strength of dominant and non-dominant leg in both intervention and control group but no significant difference was found between intervention and control group. The improvement noticed in control group was similar with the previous study of Fukuda et al. (2021) who found that the SGSP increase the gluteal abductor strength of LBP patients. However, comparison to other studies could not be made for the intervention group because this is the first study to investigate the effect of dynamic side bridge exercise on gluteus medius strength. The improvement observed in this group may be due to the dynamic side bridge exercise that has the greatest activation of gluteus medius muscle (Reiman et al., 2012). Besides, gluteus medius activation may also due to step up exercise under NGSP because this muscle acts as a synergist to provide knee and pelvis stability during step up. Hence, the gluteal abductor strength increases following intervention. As a result, NGSP is preferred over the SGSP because similar effect of gluteal muscle strength was obtained but the NGSP is more time-efficient and no equipment was required.

No difference in the improvement of gluteal muscles strength was observed following intervention in both intervention and control group. This is because both SGSP and NGSP involve the action of same gluteal muscles which were the gluteus maximus and gluteus medius. For standard program, gluteus medius was activated through the lateral straight leg raise, clamshell and lateral stepping exercise while gluteus maximus was activated by squatting (Yazbek et al., 2011). In contrast, NGSP comprised of step up that targets gluteus maximus and dynamic side-bridge that targets gluteus medius specifically (Reiman et al., 2012). Since both gluteal strengthening programs targets the same gluteal muscles, there is no significant difference in the gluteal muscle strength between intervention and control group.

### 5.2.3 Effect of different gluteal strengthening program on LBP intensity

There was a significant reduction in VAS score observed in both control and intervention group. For control group, the result was similar with the previous research by Fukuda et al. (2021) who utilised the same standard program. However, the NGSP was also effective to relieve LBP due to the strengthening effect of gluteus maximus and gluteus medius muscle. This is supported by previous research that found the LBP level reduced after prescribing a gluteal abductor strengthening exercises to LBP patients (Aboufazeli et al., 2021). However, no difference was detected for the reduction in LBP intensity between these two groups because SGSP also activates the gluteus maximus and gluteus medius muscle hence a similar effect in pain reduction was obtained.

Since the gluteus maximus and gluteus medius are closely linked to the low back function, strengthening of these two muscles tend to increase the pelvis and lumbar spine stability (Kim & Yim, 2020). Similar finding also reported by Lee & Kim (2015) who found that a reduction in LBP intensity was observed after completing the lumbar stabilization and gluteal strengthening program. Besides that, the LBP intensity may also decrease by the McGill core stabilization program that improves lumbar stability and enhances the core muscle strength (Jeong et al., 2015). Hence, it is cleared that the NGSP should be given to LBP patients to reduce their LBP because same efficacy was obtained as shown in SGSP but only two simple exercises was included and no equipment was needed in the NGSP.

#### 5.2.4 Effect of different gluteal strengthening program on functional disability

Based on the results finding, the participants in both control and intervention groups were categorized into minimal disability group because they had an ODI percentage score of less than 21%. There was a significant reduction in both ODI score and ODI percentage score observed in both control and intervention group. The reduction in ODI score in control group is consistent with the finding of previous study by Fukuda et al. (2021) that obtained the same result after completing the SGSP but the functional disability level was determined using a Roland Morris Questionnaire which has a lower test-retest reliability than ODI. Besides that, the ODI score for intervention group also significantly reduced from following intervention and the possible reason accounts for this phenomenon is due to the increase in trunk and gluteal range of motion after exercises. The finding is supported by previous research that found that the ODI disability score decreased significantly after introducing gluteal abductor strengthening exercises to LBP patients (Aboufazeli et al., 2021). However, no significant difference was found in the ODI score between intervention and control group. This is because both groups have a similar efficacy in reduction of LBP intensity as same gluteal muscles were activated thus the physical function in daily life was being improved equally. Olawale et al. (2020) highlight that the reduction in pain intensity level and improvement in pelvis as well as lumbar segmental stability causes a decrease in functional disability in daily living.

Moreover, gluteal strengthening program also improve the lumbar spine and pelvis mechanics thus relieving stress on the lumbar spine and ameliorating the physical disability when doing daily life activities (Kim & Yim, 2020). In addition, gluteal exercise was effective to improve the quality of life of low back patients and facilitate normal movement pattern by strengthening the weak gluteal muscles (Kim & Yim, 2020). The reduction in functional disability level may also due to the improvement in gluteal range of motion and pelvis stability through the gluteal strengthening program (Jeong et al., 2015). Thus, gluteal strengthening program should be prescribed to address the physical disability encountered by LBP patients because the strength of gluteal muscles was associated to the low back function. Since the NGSP consumes shorter time and no equipment is needed, it is preferred over the SGSP although both programs reduced functional disability in LBP patients.

### 5.2.5 Effect of different gluteal strengthening program on balance

There was a significant improvement in the absolute and normalized composite score for dominant and non-dominant legs observed in both control and intervention groups. However, no significant difference was found between intervention and control groups for the pre-test and post-test. Comparison with other studies could not be made because this is the first study to explore the effect of different gluteal strengthening exercises on balance with the use of Y-balance test. The improvement in balance score following intervention was supported by Jeong et al. (2015)' study who found similar result after giving lumbar stabilization and gluteal strengthening exercise to LBP participants. However, the balance performance was assessed by a Tetrax machine. The SGSP and NGSP have similar efficacy in improving the balance performance due to the increased strength in gluteal muscles thus improving the stability of pelvis in frontal and sagittal plane (Fukuda et al., 2021). Once the gluteal muscles become strong, the pelvis and lumbar spine mechanics will be improved hence balance can be achieved easily (Kendall et al., 2015). Hence, this explains the improvement in balance performance for both groups following gluteal strengthening program.

There was no significant difference in the balance score between intervention and control group following intervention because both gluteus maximus and gluteus medius were being activated in both groups. Strengthening of these two muscles may enhance the balance performance of individual. Wilson et al. (2005) proposed that the gluteus maximus was important to maintain the stability of sacroiliac joint through a self-bracing mechanism and provide dynamic joint stability by decreasing joint mobility.

Previous study also highlighted the importance of gluteus medius strengthening in improving the dynamic postural control of individual (Leavey et al., 2010). Therefore, the NGSP that targets specific gluteal muscles should be prescribed to LBP patients as it has similar efficacy as SGSP to improve the balance performance but it is a more time-efficient and only simple procedures are required.

Based on the result section, there was no significant difference between the dominant leg and non-dominant leg on the absolute composite score between both intervention group and control group during both the pre-test and post-test period. The result was similar to the normalized composite score between dominant and non-dominant leg. This finding was supported by a meta-analysis which suggests that the leg dominance does not affect the balance performance in single leg stance (Schorderet et al., 2021). This is because balance performance is not based on the muscle strength of an individual thus balance performance is the same for dominant and non-dominant leg although dominant leg has more strength compared with the non-dominant leg. Schorderet et al. (2021) proposed that the balance performance is made up of several factors such as the motor coordination, biomechanical elements including strength and endurance as well as the somatosensory information that are constantly interacting.

Moreover, this study also analysed the sex difference in Y-balance test score. As presented at the result section, the absolute and normalized composite score of dominant and non-dominant leg increased significantly following intervention in both male and female groups. However, there was no significant difference found in the improvement in absolute and normalized composite score between male and female group. This finding was supported by a meta-analysis which concluded that no sex difference was found in the composite score of Y-balance test (Plisky et al., 2021). Similar finding was reported that there was no significant difference in the average normalize reach distance observed between sex with the use of Star Excursion Balance Test (Sabin et al., 2010). The results in present study found that no sex difference in balance score because dynamic postural stability was based on the body characteristic such as the anthropometric measurement instead of the gender (Buragadda et al., 2014). No significant difference was also found in the absolute and normalized composite score between dominant and non-dominant leg in males and female group in two timelines because leg dominance does not affect the balance performance in single leg stance (Schorderet et al., 2021). As a result, gluteal strengthening program should be prescribed to LBP patients to improve their balance by increasing the muscle mobilization and postural adjustment ability so that the risk of injury can be reduced (Jeong et al., 2015).

### 5.2.6 Summary of discussion

To sum up, the null hypothesis of the current study was accepted whereas the alternative hypothesis was rejected since the significant value, $p > 0.05$ was found in all the outcome measures between control and intervention group. Hence, there is no significant difference between two gluteal strengthening programs on strength, pain, functional disability and balance among university students with non-specific chronic LBP.

The results suggest that the NGSP is equally effective in improving the strength, pain, functional disability and balance performance as how the SGSP did. However, the NGSP was considered to be a better intervention for LBP participants because NGSP only consists of two exercises and no equipment was needed for the exercise. Furthermore, the average duration to perform the NGSP is around 7 minutes, which is comparatively shorter than SGSP which consumes 15 minutes to complete all the four exercise. SGSP is time-consuming because the participants need to perform 4 types of gluteal strengthening exercises and they have to tie as well as change the position of resistant band for each exercise. Moreover, SGSP targeted all the muscles in gluteal region but NGSP only focused on gluteus maximus and gluteus medius which are weaken among LBP patients (Cooper et al., 2016). Hence, the strength of these two muscles increase thus improving the stability of pelvis and lumbar spine (Kim & Yim, 2020). This will ultimately lead to an improvement in pain, functional disability and balance performance among LBP patients.

## 5.3 Limitation of study

There are several limitations that should be considered in this research. Firstly, only university students between 18 and 25 years old were selected to be involved in this study thus limiting the generalization of findings to the other age groups. Moreover, the short period of intervention and no follow-up assessment restrict the ability to measure the long-term effect of these interventions and comparison of result cannot be made. There is also an unequal number of male and female participants in control and intervention group.

Hence, the result may not provide an accurate representation of the sex difference. Lastly, the other factors such as the physical activities and environmental factors of participants were not under control of researcher in this study.

## 5.4 Recommendation for future research

As a scope for future studies, it can be suggested that the LBP participants of a wider age range could be included so that the finding is applicable to other age group. It is recommended to lengthen the intervention period and a follow-up assessment should be conducted to compare and measure the long-term impact of these interventions. To provide the best result, an equal number of female and male participants should be allocated to the control and intervention group for comparison. Last but not least, the physical activity and other factors that may alter the result findings should be under the researcher's control and reported by the participants.

## 5.5 Conclusion

In conclusion, the present study found that the NGSP and SGSP are equally effective in improving the strength, pain, functional disability and balance performance in patients with LBP. There was a significant improvement in trunk and gluteal muscle strength, pain, functional disability and balance observed in both control and intervention group following 4 weeks of intervention. No sex difference was found in all variables.

However, NGSP was recommended instead of the SGSP because it contains a lesser number of exercises. The exercise was easy to understand and simple to conduct in any settings. Besides that, the NGSP is more time-efficient and no equipment is needed to perform the exercise but a similar efficacy in the strength improvement as SGSP was obtained. Thus, the NGSP should be introduced to university students with non-specific LBP to enhance their muscle strength thus reducing their pain and improving their functional disability as well as the balance performance.

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# APPENDIX A – ETHICAL APPROVAL FORM

**UNIVERSITI TUNKU ABDUL RAHMAN**
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Re: U/SERC/224/2022

4 November 2022

Mr Muhammad Noh Zulfikri Bin Mohd Jamali
Head, Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman
Jalan Sungai Long
Bandar Sungai Long
43000 Kajang, Selangor

Dear Mr Muhammad Noh,

**Ethical Approval For Research Project/Protocol**

We refer to your application for ethical approval for your students' research project from Bachelor of Physiotherapy (Honours) programme enrolled in course UMFD3026. We are pleased to inform you that the application has been approved under Expedited Review.

The details of the research projects are as follows:

| No | Research Title | Student's Name | Supervisor's Name | Approval Validity |
|---|---|---|---|---|
| 1. | Knowledge and Attitude Towards Overweight and Obesity Among Physiotherapy and Medical Students: A Cross-Sectional Study | Ching Yung Shan | Mr Muhammad Noh Zulfikri Bin Mohd Jamali | |
| 2. | Effects of Different Gluteal Strengthening Programs on Strength, Pain, Functional Disability and Balance Among University Students with Non-specific Chronic Low Back Pain: A Randomized Controlled Trial | Lee Kah Yi | | |
| 3. | Effects on Menstrual Cycle on Dynamic Balance and Muscle Strength Among Recreational Players | Ler Chai Hong | | |

The conduct of this research is subject to the following:

(1) The participants' informed consent be obtained prior to the commencement of the research;

(2) Confidentiality of participants' personal data must be maintained; and

(3) Compliance with procedures set out in related policies of UTAR such as the UTAR Research Ethics and Code of Conduct, Code of Practice for Research Involving Humans and other related policies/guidelines.

(4) Written consent be obtained from the institution(s)/company(ies) in which the physical or/and online survey will be carried out, prior to the commencement of the research.

Should the students collect personal data of participants in their studies, please have the participants sign the attached Personal Data Protection Statement for records.

Thank you.

Yours sincerely,

**Professor Ts Dr Faidz bin Abd Rahman**
Chairman
UTAR Scientific and Ethical Review Committee

c.c Dean, M. Kandiah Faculty of Medicine and Health Sciences
Director, Institute of Postgraduate Studies and Research

**Kampar Campus :** Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
**Tel**: (605) 468 8888 **Fax**: (605) 466 1313
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# APPENDIX B – INFORMED CONSENT FORM

Section 1 of 3

## Participants Recruitment for Research Project

EFFECTS OF DIFFERENT GLUTEUS STRENGTHENING PROGRAMS ON STRENGTH, PAIN, FUNCTIONAL DISABILITY AND BALANCE AMONG UNIVERSITY STUDENTS WITH NON-SPECIFIC CHRONIC LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL

You are invited to participate in a research study that is being conducted as part of the requirement to complete the above-mentioned Course.

Please read this information sheet and contact me to ask any questions that you may have before agreeing to take part in this study.

**Purpose of the Research Study**

The purpose of this research is to determine the effectiveness of different gluteal strengthening exercise on strength, pain, functional disability and balance among university students with nonspecific chronic low back pain. If you are an undergraduate student from UTAR Sungai long campus, you are welcomed to participate in this study.

**Procedures**

If you agree to be in this study, you will be asked to complete this questionnaire. This questionnaire will consist of 2 parts. Part I will be the demographic data of the participants while Part II will be a questionnaire to evaluate the eligibility to participate in this study.

**Length of Participation**

The questionnaire will take around 5 minutes to complete. Once the inclusion criteria is met, this study requires 6 weeks of participation with three times visit per week. Participants have to stay for around 40 minutes for each time visit.

**Benefits and Risk**

There are no known risks to participants and no direct benefits in participating in this study. However, the results generated from this study will help the healthcare professionals to formulate a more effective intervention for the treatment of non-specific chronic low back pain patients to improve their quality of life.

**Confidentiality**

No information that will make it possible to identify you, will be included in any reports to the University or in any publications.

Research records will be stored securely and only approved researchers will have access to the records.

**Voluntary Nature of the Study**

Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

**Contacts and Questions**

If you have any questions, clarifications, concerns or complaints, about the research, the researcher conducting this study can be contacted at 012-2131880 or kahyilee@1utar.my.

Email

Short answer

Please register using your UTAR email (e.g. lee@1utar.my)

Short-answer text

Required

# APPENDIX C – PERSONAL DATA PROTECTION NOTICE

**Personal Data Protection Statement**

Please be informed that in accordance with Personal Data Protection Act 2010 ("PDPA") which came into force on 15 November 2013, Universiti Tunku Abdul Rahman ("UTAR") is hereby bound to make notice and require consent in relation to collection, recording, storage, usage and retention of personal information.

1. Personal data refers to any information which may directly or indirectly identify a person which could include sensitive personal data and expression of opinion. Among others it includes:

a) Name
b) Identity card
c) Place of Birth
d) Address
e) Education History
f) Employment History
g) Medical History
h)Blood type
i) Race
j) Religion
k) Photo
l) Personal Information and Associated Research Data

2. The purposes for which your personal data may be used are inclusive but not limited to:
a) For assessment of any application to UTAR
b) For processing any benefits and services
c) For communication purposes
d) For advertorial and news
e) For general administration and record purposes
f) For enhancing the value of education
d) For advertorial and news
e) For general administration and record purposes
f) For enhancing the value of education
g) For educational and related purposes consequential to UTAR
h) For replying any responds to complaints and enquiries
i) For the purpose of our corporate governance
j) For the purposes of conducting research/ collaboration

3. Your personal data may be transferred and/or disclosed to third party and/or UTAR collaborative partners including but not limited to the respective and appointed outsourcing agents for purpose of fulfilling our obligations to you in respect of the purposes and all such other purposes that are related to the purposes and also in providing integrated services, maintaining and storing records. Your data may be shared when required by laws and when disclosure is necessary to comply with applicable laws.

4. Any personal information retained by UTAR shall be destroyed and/or deleted in accordance with our retention policy applicable for us in the event such information is no longer required.

5. UTAR is committed in ensuring the confidentiality, protection, security and accuracy of your personal information made available to us and it has been our ongoing strict policy to ensure that your personal information is accurate, complete, not misleading and updated. UTAR would also ensure that your personal data shall not be used for political and commercial purposes.

Consent:
6. By submitting or providing your personal data to UTAR, you had consented and agreed for your personal data to be used in accordance to the terms and conditions in the Notice and our relevant policy.

7. If you do not consent or subsequently withdraw your consent to the processing and disclosure of your personal data, UTAR will not be able to fulfill our obligations or to contact you or to assist you in respect of the purposes and/or for any other purposes related to the purpose.

Acknowledgement of Notice *

○ I have been notified by you and that I hereby understand, consent and agreed per UTAR above notice.

○ I disagree, my personal data will not be processed.

Electronical Signature (eg: electronically s/d kahyi) *

Short-answer text

Name *

Short-answer text

IC no. *

Short-answer text

Date *

Day, month, year

# APPENDIX D – QUESTIONNAIRE FORM (DEMOGRAPHICS)

Section 2 of 3

**Demographic Data**

Description (optional)

Age *

Short-answer text

Gender *

- Male
- Female
- Other...

Ethnicity *

- Chinese
- Malay
- Indian
- Other...

Contact number *

e.g. 012-1234567

Short-answer text

Student ID *

e.g. 19UMB00000

Short-answer text

Which faculty are you from *

- MK FMHS
- LKC FES
- FAM
- FCI
- CFS
- FAS
- FBF
- FECT
- FICT
- FSC
- ICS
- IPSR
- Other...

What is your height? (in cm) *

Short-answer text

What is your weight? (in kg) *

Short-answer text

# APPENDIX E – SCREENING TOOL

Section 3 of 3

**Screening tool**

This section is created to determine the eligibility to participate in this study.

Do you have low back pain in the past 12 weeks (3 months)? *

- ○ Yes
- ○ No

Do your low back pain radiates down to the legs? *

- ○ Yes
- ○ No

Do you undergo any surgery injury to your trunk, stomach or hip in the past 6 months? *

- ○ Yes
- ○ No

Do you have spine or hip fracture in the past 3 months? *

- ○ Yes
- ○ No

Do you have any spinal deformities (eg. scoliosis, spondylolysis, prolapsed intervertebral disc, etc) or signs of neurological deficit? *

- ○ Yes
- ○ No

Are you taking corticosteroids/ anti-inflammatory medication? *

- ○ Yes
- ○ No

Are you taking corticosteroids/ anti-inflammatory medication? *

- ○ Yes
- ○ No

Please rate your low back pain score according to the Visual Analogue Scale (VAS) scale below: *

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no pain | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | excruciating pain |

# APPENDIX F – VAS

Please rate your low back pain score according to the Visual Analogue Scale (VAS) scale below: *

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no pain | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | excruciating pain |

# APPENDIX G – ODI

## Oswestry Disability Index (ODI)

Instructions: this questionnaire has been designed to give us information as to how your back pain has affected your ability to manage everyday life. Please answer every section and mark in each section only the ONE box which applies to you at this time. We realize you may consider 2 of the statements in any section may relate to you, but please mark the box which most closely describes your current condition.

Email *

Valid email address

This form is collecting email addresses. Change settings

**PAIN INTENSITY** *

- ◯ I can tolerate the pain I have without having to use pain killers
- ◯ The pain is bad but I manage without taking pain killers
- ◯ Pain killers give complete relief from pain
- ◯ Pain killers give moderate relief from pain
- ◯ Pain killers give very little relief from pain
- ◯ Pain killers have no effect on the pain and I do not use them

**PERSONAL CARE** (e.g. Washing, Dressing) *

- ◯ I can look after myself normally without causing extra pain
- ◯ I can look after myself normally but it causes extra pain
- ◯ It is painful to look after myself and I am slow and careful
- ◯ It is painful to look after myself and I am slow and careful
- ◯ I need some help but manage most of my personal care
- ◯ I need help every day in most aspects of self care
- ◯ I don't get dressed, I was with difficulty and stay in bed

**LIFTING** *

- ◯ I can lift heavy weights without extra pain
- ◯ I can lift heavy weights but it gives extra pain
- ◯ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positi...
- ◯ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conve...
- ◯ I can lift very light weights
- ◯ I cannot lift or carry anything at all

**WALKING** *

- ◯ Pain does not prevent me walking any distance
- ◯ Pain prevents me walking more than one mile
- ◯ Pain prevents me walking more than ½ mile
- ◯ Pain prevents me walking more than ¼ mile
- ◯ I can only walk using a stick or crutches
- ◯ I am in bed most of the time and have to crawl to the toilet

**SITTING** *

- ◯ I can sit in any chair as long as I like
- ◯ I can only sit in my favorite chair as long as I like
- ◯ Pain prevents me from sitting more than 10 minutes
- ◯ Pain prevents
- ◯ Pain prevents me from sitting at all
- ◯ Pain prevents

**STANDING** *

- I can stand as long as I want without extra pain
- I can stand as long as I want but it gives me extra pain
- Pain prevents me from standing for more than one hour
- Pain prevents me from standing for more than 30 minutes
- Pain prevents me from standing for more than 10 minutes
- Pain prevents me from standing at all

**SLEEPING** *

- Pain does not prevent me from sleeping well
- I can sleep well only by using medication
- Even when I take medication, I have less than 6 hrs sleep
- Even when I take medication, I have less than 4 hrs sleep
- Even when I take medication, I have less than 2 hrs sleep
- Pain prevents me from sleeping at all

**SOCIAL LIFE** *

- My social life is normal and gives me no extra pain
- My social life is normal but increases the degree of pain
- Pain has no significant effect on my social life apart from limiting my more energetic interests, i.e. danci...
- Pain has restricted my social life and I do not go out as often
- Pain has restricted my social life to my home
- I have no social life because of pain

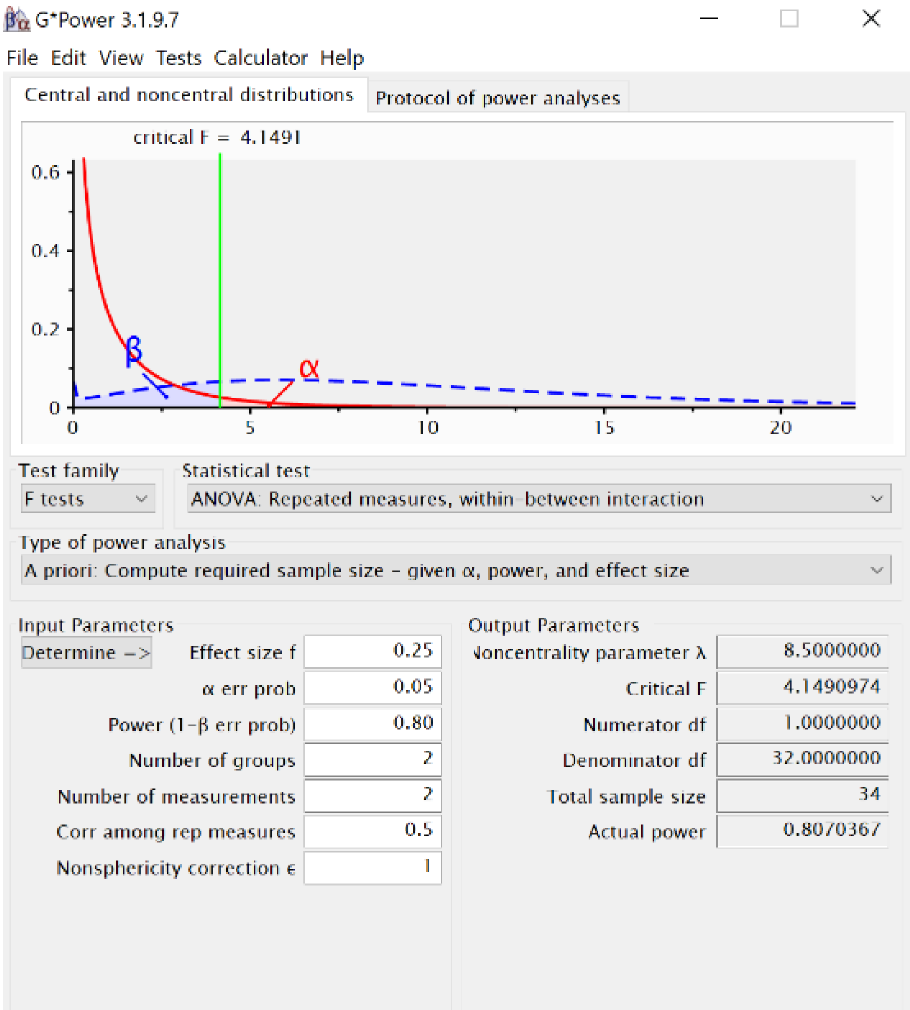
**TRAVELLING** *

- I can travel anywhere without extra pain
- I can travel anywhere but it gives me extra pain
- Pain is bad, but I manage journeys over 2 hours
- Pain restricts me to journeys of less than 1 hour
- Pain restricts me to short necessary journeys under 30 minutes
- Pain prevents me from traveling except to the doctor or hospital

**EMPLOYMENT/ HOMEMAKING** *

- My normal homemaking/ job activities do not cause pain
- My normal homemaking/ job activities increase my pain, but I can still perform all that is required of me
- I can perform most of my homemaking/ job duties, but pain prevents me from performing more physical...
- Pain prevents me from doing anything but light duties
- Pain prevents me from doing even light duties
- Pain prevents me from performing any job or homemaking chores

# APPENDIX H – G POWER ANALYSIS



## APPENDIX I – TURNITIN REPORT

# EFFECTS OF DIFFERENT GLUTEAL STRENGTHENING PROGRAMS ON STRENGTH, PAIN, FUNCTIONAL DISABILITYAND BALANCE AMONG UNIVERSITY STUDENTS WIITH NON-SPECIFIC CHRONIC LOW BACK PAIN

*by* Kah Yi Lee

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