TAN BEE THONG

RELATIONSHIP BETWEEN FLAT FOOT WITH ANTERIOR PELVIC TILT AND SACOILIA JOINTS DYSFUNCTION AMONG UNGRADUATE STUDENTS

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A CORRELATION STUDY OF THE RELATIONSHIP BETWEEN FLAT FOOT WITH ANTERIOR PELVIC TILT AND SACROILIAC JOINTS DYSFUNCTION AMONG UNDERGRADUATE STUDENTS

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By

TAN BEE THONG

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A CORRELATIONAL STUDY OF THE RELATIONSHIP BETWEEN FLAT FOOT WITH ANTERIOR PELVIC TILT AND SACROILIAC JOINTS DYSFUNCTION AMONG UNDERGRADUATE STUDENTS

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ABSTRACTS

Background: Flat foot is a common observed clinical foot.The medial longitudinal arch becomes flatter or absence among the flat foot individuals. As the foot mechanic altered, it might affect the alignment of lower limbs up to pelvis. It led to medial rotation of hip and knee, and subsequently cause anterior pelvic tilt. The excessive forward rotation of pelvic might place more load over the sacroiliac joints and cause pain and dysfunction. The purpose of conducting this research is to determine the relationship between flat foot with anterior pelvic tilt and sacroiliac joints among undergraduate students.

Methods: Screening booth was built in UTAR, Sungai Long Campus. The undergraduate students with unilateral or bilateral flat foot were recruited in this study. The CSI, tri-goniometirc method, Shimpi Prone SIJ test were used to assess the flat foot, degree of anterior pelvic tilt, and sacroiliac joints dysfunction.

Results: There were 98 participants in total diagnosed with flat foot deformity. There was 55.7% of prevalent of flat foot deformity among undergraduate students. There was only fair and positive significant difference was found between anterior pelvic tilt and sacroiliac joints dysfunction among third degree of flat foot participants ($r=0.555$, $p=0.009$).

Conclusion: Majority of severe form of flat foot subjects were found with higher BMI index and diagnosed bilaterally. In addition, the relationship between anterior pelvic tilt and sacroiliac joints dysfunction only occurred among the flat foot subjects with more severe degree.

Key Words: Anterior pelvic tilt, Sacroiliac Joints Dysfunction, Flat Foot, Undergraduate Students, Relationship

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PERMISSION SHEET

It is hereby certified that **TAN BEE THONG** (ID No: **20UMB03313**) has completed this Research project entitled "A CORRELATIONAL STUDY OF THE RELATIONSHIP BETWEEN FLAT FOOT WITH ANTERIOR PELVIC TILT AND SACROILIAC JOINT DYSFUNCTION AMONG UNDERGRADUATE STUDENTS" under the supervision of Dr. Deepak Thazhakkattu Vasu from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health sciences.

Yours truly,

(TAN BEE THONG)

_____

APPROVAL SHEET

This Research project entitled "**A CORRELATIONAL STUDY OF THE RELATIONSHIP BETWEEN FLAT FOOT WITH ANTERIOR PELVIC TILT AND SACROILIAC JOINT DYSFUNCTION AMONG UNDERGRADUATE STUDENTS**" was prepared by TAN BEE THONG and submitted as partial fulfillment of the requirements for the degree of Bachelor of Physiotherapy (Honours) at Universiti Tunku Abdul Rahman.

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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.

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LIST OF ABBREVIATION

CSI	Chippaux-Smirax Index
APT	Anterior pelvic tilt
ASIS	Anterior superior iliac spine
PSIS	Posterior superior iliac spine
LBP	Low back pain
MLA	Medial longitudinal arch
LLA	Lateral longitudinal arch
SIJ	Sacroiliac Joints
UTAR	Universiti Tunku Abdul Rahman

CHAPTER 1

INTRODUCTION

1.1 Background

1.1.1 Definition of Flat Foot Deformity

Flat foot deformity, which also called as pes planus, is a common foot observed disorder in the clinical practice. This condition can also be called as pronated foot and fallen arch. Pes planus which is the medical term of flat foot deformity. It referred as the curvature of medial longitudinal arch is more flatten than normal arch. It is a condition described the absence of medial longitudinal arch of the foot, heel valgus deformity, and medial talar prominence.

In fact, the foot arches in human beings consist of medial longitudinal arch (MLA), lateral longitudinal arch (LLA), and anterior transverse arch, whereas the medial longitudinal arch plays an important role among these foot arches during ambulating (Babu & Bordoni, 2020). Basically, the structure and dynamicity of

the foot arches are crucial for lower limbs' function, especially on foot. The major function of the foot arches consists of shock absorption, body weight transmission, and acting as a lever to move the body forward during ambulation. Mainly, these foot arches play the role as a spring function to distribute the body weight and stress during walking, running, or performing physical activities. In nature, the MLA is higher than LLA and it flatten the curvature to different degrees during weight bearing. The height of MLA also as an indicator to evaluate the severity and degree of flat foot disorder.

Besides, the foot structures and postures of flat foot populations are significantly different with normal healthy individuals. The foot shape considers as an essential cause of determining the foot loading. Ideally, the distribution of forces prone to be uniform in a perfect neutral foot. The force distribution was affected when the foot shape was altered and deformed. Some specific areas will be overloaded with the imbalance forces and stress. For instance, traction forces tend to load the structures on the medial side of the ankle in a flat foot, while compression forces are enhanced across the lateral side of the ankle and hindfoot (Biomechanics, Foot & Ankle: Musculoskeletal Medicine, n.d.). In anatomical view, the forefoot and hind foot are connected by tough, elastic ligaments, tendons, and fascia. Among the flat foot individuals, there is an imbalance forces that result the foot arch flatten. This condition might cause to the absence and loss of the medial longitudinal arch. The incidences of developing flat foot will be increased in associated with the arch flattening effect of the triceps surae and the

increased of the body weight. Moreover, the weakness of muscular, ligamentous, or bony arch supporting also was known as one of the cause factors leading to the foot arch flattening. There were numerous variables were associated to etiology of flat foot, which can be either congenital or acquired (Troiano et al., 2017). The flat foot deformity brings many negative impacts and affects the quality of life. Moreover, the flat foot is a foot disorder which can be hereditary or progressive developed throughout lifetime.

1.1.2 Rigid Flat Foot

Adult acquired flat foot deformity (AAFD), also known as rigid flat foot. It considers as a degenerative disease which due to the pathological changes in tibialis posterior tendon, spring ligament complex, deltoid ligament, and others supporting ligaments of the hindfoot (Tao et al., 2019). Among them, rupture or dysfunction of the posterior tibial tendon was the main causing factor. The posterior tibial tendon which is the major supporting structure of the foot arch. Injuries of the tendon can lead to arch flattening and ankle rolling in. Apart from this, the rigid flat foot also may arise due to diabetes, arthritis, spina bifida, cerebral palsy, Arthrogyroposis, traumatic injury, muscular atrophy excessive tension in the triceps surae, and overweight. Mainly, this condition occurred among adult populations. The individuals with rigid flat foot, their foot arch is absence in both weight bearing and non-weight bearing position due to the

immobility of the subtalar joint (TheCenter, 2020). Generally, flexible flat foot occurred bilaterally while the rigid flat foot can be formed either unilaterally or bilaterally (Berlet, 2021). Besides, the rigid flat foot will result of tarsal coalition. The tarsal coalition is a condition characterized by two or more bones in the middle or back of the foot fused together.

1.1.3 Flexible Flat Foot

The congenital flat foot also called as flexible flat foot and pediatric flat foot. It is an idiopathic condition. The flexible flat foot was considered as one of the most prevalent types of flat foot. It also very commonly be observed among children. It usually began in childhood or adolescence and sometimes lasted to adulthood. The arising of flexible flat foot mainly due to the osseous and ligament laxity, immature neuromuscular control, as well as the presence of adipose tissue below the medial longitudinal arch. The adipose tissue that presence under the MLA is used to protect the foot arch of infants. The flexible flat foot is differed from rigid flat foot (Banwell et al., 2018). In the flexible flat foot, the foot that has a normal arch during resting but absence when the foot in weight bearing and contacted with the surface of ground. In nature, the children ambulate with the entire foot. They were more balance as the base of surface was wider. Their foot arches will become more prominent when their feet start to weight bearing. However, most of the children develop the arches as they grow. Their arches are

developed and structurally mature around 12 to 13 years old. Basically, the flexible flat foot is asymptomatic but a small number of the population experience painful when walking and standing for long period of times. Currently, the major causes that cause flexible flat foot is still unknown, sometimes it runs in families. The boys have greater chances in developing flat foot than girls (Flexible Flatfoot | Boston Children's Hospital, n.d.).

1.1.4 Complications of Flat Foot

The flexible flat foot deformity is typically asymptomatic and cures in the first decade of life, but in some cases, the condition become worsen and progressed into painful and impaired the lower limbs' function. In this case, it can seriously impair individual ability and functionality. As the deformity become worsen, the supporting tendons and ligaments of the foot arch may overstretch, injured, and inflamed. The flat foot deformity altered the structure of the foot arch. The alternation led to various of complications, including presence of pain, swelling, bony deformities, postural change, abnormal gait pattern and others.

As mentioned before, the flat foot deformity is an observed foot condition. When observed a flat foot individual, their foot is flatter than healthy subjects, and the total sole is contact with the ground. The calcaneal valgus is more obvious, the medial longitudinal arch appears to drop and foot eversion occurred. These

presentations were more apparent when the individuals were in standing position. Besides, the bunions and hammer toes also may form among the flat foot individuals. Apart from this, the Achilles tendon contracture also known as one of the indicators of the flat foot. The contracted Achilles tendon limited the dorsiflexion of ankle in order to affect the balancing of the individuals.

When the foot was structurally altered and deformed due to the flat foot deformity, there were some changes in the angle of the joints in the hip, knee, and ankle. These changes increased the risk of developing hips, knees, and ankles pain. These abnormal changes may place more stress and load over the joints and lead to develop a poor posture, such as anterior pelvic tilt, genu valgum and others. According to Ghasemi et al. (2016), overpronation of foot will result in excessive medial rotation of hip and knee then lead to excessive anterior pelvic tilt. Among the flat foot individuals, their feet prone to be in an eversion position and consequently cause the shin bone medially rotated and came together in order to deform as genu valgum. As the mechanic was altered, the pelvic alignment also tends to tilt in the forward direction to compensate the abnormal postural alignment.

Pelvic tilt is described about the degree formed by a line from the midpoint of the sacral endplate to the centers of the bifemoral heads and the vertical axis, and it depends on the position of the pelvis (Pelvic Tilt, n.d.). Flat feet deformity was

most prominently contributed to either anterior or posterior pelvic tilt, which is known as a disorder of the pelvis rotates excessively in forward or backward direction. Anterior pelvic tilt (APT), also known as forward pelvic tilt, which referred to a short-arc anterior rotation of the pelvis that occurs with the trunk held stationary. The anterior superior iliac spine (ASIS) tilts lower than the neutral position while the posterior superior iliac spine (PSIS) raises upward. The excessive anterior pelvic tilt also associated with few musculoskeletal problems. The muscles imbalance may result in feet, ankle, knee, as well as back problems. In the anatomical view, the excessive pelvic tilt was results from an unbalanced set of muscles acting on the pelvis or lumbar area (Anterior Pelvic Tilt - an Overview | ScienceDirect Topics, 2019). The anterior pelvic tilt often associated with abnormally hips internal rotation and shortening of hip flexors and quadriceps. This malalignment also because of the weakness of gluteus maximus and hamstring and lead to lack of support to opposing muscles. Besides, APT also may lead to spinal issues, such as the lumbar lordosis was also exacerbated by the increased of anterior pelvic tilt (Mukai & MD, n.d.).

Moreover, the anterior pelvic tilt misalignment results in increasing both lower spine and upper back curvature (Anterior Pelvic Tilt: Fixes, Causes, and Symptoms, 2017). In this way, it may lead to inadequate lumbar spine support, which will cause some chronic sicknesses and back issues (MyChiroPractice, n.d.). The most common complaint of excessive pelvic tilt was acute and chronic low back pain. There was a previous study shown that, there was more than one

clinical disease or pathology associated conditions with excessive anterior pelvic tilt. Among the individuals with excessive anterior tilt and experienced low back pain, the lowest two levels, L4 – L5 and L5 – S1 has mostly been affected. The excessive anterior pelvic tilt was disrupting the kinetic chain and affect the interaction of joints, muscles, and body segments (*Tilted Pelvis: Symptoms, Treatments, and Distinctions*, n.d.). In short, the excessive anterior pelvic tilt due to the muscles imbalance and result in feet, ankle, knee, as well as back problems (Does Anterior Pelvic Tilt Cause Back Pain, 2017). However, the anterior pelvic tilt was a susceptibility as one of the risk factors of developing unspecific low back pain (LBP) and pelvic girdle pain. Moreover, it also suspected as a factor of leading to femoroacetabular impingement, low back pain, and sacroiliac joint dysfunction (Falk Brekke et al., 2020).

Pain, which is the most common complaint from flat foot populations, especially from the rigid flat foot. The pain and soreness usually arise from the foot arch, heel, and ankle. It will be worsened and severe with a long period of standing, walking and performing the extensive physical activities (Flatfeet - Symptoms and Causes, n.d.). In rigid flat foot, the pain and swelling usually present in the inside arch of the foot and ankle. After that, the joints over the foot and ankle may eventually develop arthritis. Arising of these signs and symptoms might lead to the progression and worsening of the rigid flat foot. Some of the flat foot individuals experienced foot cramp at night. It may be due to the strained muscles and structures in midfoot, heel, legs, knees, hips, or back. Some of them

also presence with edema over the heel and ankle region. Besides, the overpronation of foot cause the alternation of the lower extremities alignment. The abnormally medial rotation of hip may cause hip pain as well as inflammation of sacroiliac joint which may lead to low back pain (Foot Dysfunction: How Overpronation & Oversupination Cause Chronic Back Pain, n.d.). In some severe cases, the pain radiates down throughout the lower limbs (Understanding Sacroiliac Joint Issues: Southern Pain Specialists: Interventional Pain Management Specialists, n.d.).

In some severe cases, the gait pattern was alternated. The abnormal gait patterns mainly due to the structural changes in foot such as excessive pronation of foot (flat foot) and excessive supination of foot (duck foot). Moreover, the abnormal gait pattern also considered as one of the cause factors in developing sacroiliac joint dysfunction.

The sacroiliac joints (SIJ) are formed by iliac and sacrum bones and located at both right and left of the lower back. The joints form a connection between spine and pelvis and contributing as a shock absorber. The joints responsible to transfer the load and stress between spine and lower limbs. Besides, the sacroiliac joint only allows minor movement which responsible in forward and backward bending action. Based on the anatomical view of the SIJ, the range of motion (ROM) of the SIJ is around 3° in flexion-extension direction, around 1.5° in axial rotation,

and around 0.8° in lateral flexion. Mainly, it responsible to maintain the body weight and distribute external forces, such as during lifting, uniformly across the pelvis to relieve pressure on lumbar spine. Besides, it also assists in absorbing shock and impact, such as sporting, landing. So, it was more prone to be pain and injured.

Sacroiliac joints dysfunction is a condition that characterized the hypermobility and hypomobility of the SIJ. The patient who diagnosed with SIJ dysfunction, he or she may experience the pelvic feeling unstable, pelvic girdle pain, as well as stiffness over the SIJ region. The disorder was more prone to middle-aged women, especially who are pregnant or have given birth (Yeomans, 2013). According to a study from Raj & Varacallo (2019), there was more than 25% of low back pain cases were caused by SIJ dysfunction. In fact, the symptoms of SIJ dysfunction were varied from person to person. The pain usually arises from lower back, upper buttocks region and radiates to legs. The characteristics of pain also different, some of them complaint of dull and achy sensation whereas others complaint of stabbing and sharp pain in nature. In some more severe cases, the pain will be radiated down into hip, groin, and back of upper thigh region. It also will associate with feelings of tightness, stiffness, burning, tingling, numbness, and weakness over the affected area (Everything You Need to Know about the Sacroiliac Joints and Sacroiliac Joint Pain, n.d.). Besides, sacroiliac joint disorders may arise due to additional strain on the joint, such as osteoarthritis, pregnancy, lower back problem, trauma or injury, leg length discrepancies (LLD),

inflammatory conditions (Sacroiliac Joint Disorder - Pelvis - Conditions - Musculoskeletal - What We Treat - Physio.co.uk, n.d.).

In a nutshell, the flat foot deformity brought various of negative impacts to the affected population. The alternation of the foot structure and posture affect lower limbs chain of mechanics and led to formation of poor posture. Anterior pelvic tilt was known as one of the postural changes among the flat foot individuals. With the progression and worsening of the condition, the abnormal stress and load place on the sacroiliac joints may increase and lead to injury and dysfunction.

1.1.5 Assessment

In current, there are different screening procedures are used in clinical settings to diagnose flat foot condition, such as radiography, physical examinations, footprints, gait analysis, plantar pressure, and pedobarographic measurements. Among them, the screening is mostly focus on the medial longitudinal foot arch and heel angle. The visual assessment method was known as the most general, costless, and convenience method to assess flat foot but it was less accurate than other methods. The assessor observed their foot arches from multidirectional perspective during weight bearing and non-weight bearing positions. The visual assessment assessed through naked eyes instead of a feasible measurement scale. Moreover, this method lacks the subjective data to be analyzed.

Besides, the radiography was considered as a more accurate method to assess flat foot deformity. This method is costly and more suitable to be used in laboratory settings. The X-rays imaging, which consider as a type of electromagnetic wave, are useful in examine internal body structures that cannot be observed through naked eyes by penetrating the electromagnetic radiation (X-Rays, n.d.). The standing foot X-rays was appropriate to be used in determining the degree of foot deformity, particularly in standing lateral view and standing anteroposterior (AP) view. The X-rays findings result from flat foot will usually show the loss of normal straight-line relationship with Meary's angle, sagging at the talonavicular or naviculocuneiform joints, disruption of the cyma line (Weerakkody, n.d.).

Next, footprints method was considered as a more simple and easier assessment method to perform in universities since it does not require any expensive and professional equipment. Besides, the footprints can be assessed through different assessment scales, such as valgus index, arch index, Staheli arch index, Chippaux-Smirak index, foot posture index and Clarke's angle. These assessment scale identified the flat foot by using several reference points that exist on the footprints. Among them, the Clarke's angle and Chippaux-Smirax index were reported had higher validity and reliability to assess the flat foot deformity. These two footprints-based methods were widely be used as the assessment tool

for flat foot screening. Hence, both techniques required static and clear footprints of the subjects.

The Clarke's angle was described as an angle formed by the medial footprint's tangent and the line joining the greatest perpendicular distance from the medial border of the foot and the location where the medial tangent crosses the front foot's boundary. According to Hegazy et al. (2021), the Clarke's angle was classified according to the footprint's measurement into normal (42 to 54 degrees), mild (35 to 41 degrees), moderate (30 to 34.9 degrees), severe (less than 30 degrees), and high arch consider as more than 54 degrees.

In another hand, the Chippaux-Smirax index was calculated according to the ratio of the greatest support width of metatarsals to the least support width of the center of the foot arch. These landmarks need to be measured accurately for the precise calculation. The degree of the severity of the flat foot was depends on the percentages of the CSI. The first degree of flat foot was between 45.1% to 50.0%; the second degree of flat foot was between 50.1% to 60.0%; the third degree of flat foot was between 60.1% to 100.0%. The first degree of normal foot was between 0.1% to 25.0%; the second degree of normal foot was between 25.1% to 40.0%; the third degree of normal foot was between 40.1% to 45.0%. Lastly, the absence of the middle part of foot, indicating high foot.

As mentioned before, the alternation of foot structures among the flat foot population also affected the pelvic alignment. In current, there are few methods are available to assess the pelvic tilting degree, include radiography, visual observation assessment, hand-held inclinometer, caliper-based pelvic inclinometer, and smartphone application ("iHandy Level). Most of the assessment tools for identifying the degree of pelvic tilt require clinical equipment to gain the more accurate data. However, the clinical equipment is expensive and unaffordable for some small settings. In fact, the radiography method is one of the most accurate methods to assess the pelvic tilting, as it can directly calculate the degree through the imaging. However, the X-rays' imaging method is costly and difficult to apply in this setting.

PALM palpation meter is a type of the caliper-inclinometer assessment tool that suitable used in clinical settings. It is quite expensive assessment tools and unaffordable for some small settings. The palpation meter is a reliable and valid instrument for assessing the difference height of pelvic crest and pelvic tilt (Hayes et al., 2016). Besides, the handheld caliper also widely be used in assessing degree of pelvic tilt.

Therefore, there are few smartphones' applications were invented to assess the degree of pelvic tilt. Mainly, the applications were assessed through the photography and picture of the pelvic orientation. The application which called

"iHandy Level" was used in measuring the standing pelvic position and found with excellent intra-rater reliability (Suits, 2021). Besides, the postural assessment software (PAS/SAPO) was a software that used to assess the postural alignment. It considered as a reliable tool for postural assessment (Ferreira et al., 2010). However, this software is not offering English version, so it is difficult to perform with this application with a foreign language.

Besides, the tri-goniometric method is considered as one of the easier, costless, and reliable tools for assessing the degree of pelvic tilt. This method does not require much equipment. Mainly, this method based on the tri-goniometric mathematical calculation to measure the degree of pelvic tilt. The only requirement for applying this technique is the assessor should be able to palpate and identify the bony landmarks: anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS). The degree of pelvic tilt was measured based on the tri-goniometric formula. Besides, this method also had higher validity and reliability in measuring degree of pelvic tilt (Thiruvarangan et al., 2017).

As mentioned before, the abnormal position of pelvic may put more stress and load over the sacroiliac joints. It may cause the sacroiliac joints dysfunction. The sacroiliac joints only allow minor movement. Therefore, it is hard and difficult to assess when compared to the other joints. There was a study showed that the gold standard of sacroiliac joint dysfunction diagnosing was a diagnostic nerve block

(Sacroiliac Joint Special Test Cluster, n.d.). The diagnostic nerve block requires trained medical practitioners and some specific equipment. It requires anesthetic injection into the SIJ which is not suitable to perform in physiotherapy field. Other than this, the physical examination also can be an associate factor to confirm the SIJ dysfunction.

Therefore, there are few provocative tests for SIJ. The tests consist of FABER test (also known as Patrick's test), Thigh Thrust Test (also known as posterior shear test), Gaenslen test, comprehension test, distraction test and Yeoman test (Buchanan et al., 2021). In a nutshell, Shimpi prone SIJ test is a latest clinical test to measure SIJ dysfunction. This new clinical test is more suitable in applying among various population, such as obese patients, the patients with poor stability, and elderly. This test requires the patient to prone lying on a bed. This position does not demonstrate any difficulties for instability or balance concerns for the patients. The Shimpi Prone SIJ test consists of the action at lumbosacral junction and permits hip extension at acetabulofemoral joint by causing a SIJ counter-nutation motion. This assessment is considered positive when the patient reproduces normal pain meanwhile the femoral nerve may be stressed.

1.2 Objective of Study

The general objective of this study was to determine the relationship between anterior pelvic tilt and sacroiliac joint dysfunction among young adults with flat foot.

1.3 Research Question

The research question of this study was:

Does the sacroiliac joint dysfunction influence in developing anterior pelvic tilt among young adults with flat foot?

1.4 Hypothesis

1.4.1 Null Hypothesis

There is no correlation between sacroiliac joint dysfunction and anterior pelvic tilt in undergraduate students with flat foot.

1.4.2 Alternative Hypothesis

There is a correlation between sacroiliac joint dysfunction and anterior pelvic tilt in undergraduate students with flat foot.

1.5 Operational Definition

Flat foot, also known as pes planus. It is a common observed foot deformity. It may develop during childhood or lasted throughout adulthood. It is a condition when the foot loses the medial longitudinal foot arch and cause the entire sole contact with the ground surface during weight bearing position (Raj et al.).

Anterior pelvic tilt (APT) is a clinical term of postural change. It refers to the front pelvis rotated or tilted forward whereas the back of the pelvis elevated ("Anterior Pelvic Tilt: Fixes, Causes, and Symptoms", 2017).

Sacroiliac joint is the joint that made up of sacrum and ilium bones, which connects the spine and pelvis. It is located at both left and right side over your lower back. It only permits a small amount of motion in flexion-extension, lateral flexion, and axial rotation directions. The major role of the joint is act as a shock absorber, transmitting the force between body and lower limbs. (Sacroiliac Joints, n.d.).

Sacroiliac joints dysfunction is a condition that refers to pain over the sacroiliac joints region when the joints are hypermobility or hypomobility. This condition may result in low back pain, legs pain, as well as inflammation of the sacroiliac joints (sacroiliitis). It is more prevalent among young adults, middle-aged women, and the women who are pregnant (Yeomans, 2013).

1.6 Rationale of Study

Flat foot deformity has altered the foot mechanic and lead to alternation of the low limbs alignment and up to the pelvic girdle and spine of the affected individuals. According to the studies above, it was shown that flat foot populations had a higher risk of developing anterior pelvic tilt than healthy individuals (Eldesoky & Abutaleb ,2015). There was also a study reported that there was around 49.3% of prevalence in developing sacroiliac joint dysfunction among flat foot patients. Sacroiliac joints are the joints that connected the spine and pelvis which are highly associated with the pelvic orientation. The primary mechanism of sacroiliac joint dysfunction is hypermobility and hypomobility of the sacroiliac joints whereas it may lead to pelvic instability, low back pain, and other complications (Steven Yeomans, DC). According to Król et al. (2017), the incidence of anterior pelvic tilt is highly correlated with the incidences of low back pain. Besides, from the research done by Barros et al. (2019) showed that there was 15% to 30% of low back pain people were found associated with sacroiliac joint dysfunction. So that, it was a susceptibility regarding the sacroiliac joint dysfunction considered as one of the causing factors to anterior pelvic tilt misalignment as well as low back pain among flat foot populations.

Based on the studies above, it is important to rule out the correlation of flat foot with anterior pelvic tilt and sacroiliac joint dysfunction. This association can

help the flat foot populations to prevent associated low back pain and improve the quality of life and postural awareness. In regards, increased awareness of flat foot deformity may help the flat foot populations to understand of the complications of flat foot, which can assist them to have early intervention and prevent the worsen of symptoms. Besides, the result of this study benefits the physiotherapists who are treating flat foot conditions and would not neglect the SIJ and pelvic orientation while treating the flat foot patients with low back pain.

Currently, there was a related study was done and shown that flat foot individuals had trend of increasing pelvic inclination when compared to the normal healthy individuals. There was also a study shown that sacroiliac joint dysfunction was 49.3% prevalence among flat foot populations. However, currently there was not any related research was done regarding the correlation between anterior pelvic tilt and sacroiliac joint among the flat foot populations. So, the aim of conducting this research is to define the correlation of flat foot with anterior pelvic tilt and sacroiliac joint dysfunction among young adults.

1.7 Scope of Study

Nowadays, flat foot deformity is known as a common observable foot condition that can found among childhood as well as adulthood. According to the research that have been done before, there were approximately one third of populations will be diagnosed as flat foot deformity. Since most of the flat foot

are considered as flexible flat foot and asymptomatic thus it will always be ignored and neglected by the public as most of them are lack of the knowledge about the deformity. In addition, some of the left untreated cases, the complications will be worsened and affected other body parts, particularly the pelvic orientation. For example, alternation of foot mechanic will lead to abnormal compensation and stress on lower limbs and resulting pain, discomfort and induces the risk of excessive anterior pelvic tilt. So, this study focuses on the sacroiliac joint mobility as an underlying risk factor among flat foot populations of increasing risk of developing anterior pelvic tilt malalignment. The purpose of conducting this research is to determine that the sacroiliac joint dysfunction as one of the underlying factors which is correlated in developing anterior pelvic tilt among the young adults. The result of this study helps the public as well as the flat foot patients to increase the awareness and knowledge about flat foot deformity. Moreover, they can have early intervention and prevent worsening of the deformity. Besides, result of this study also can provide a clear idea to the therapists on treating flat foot patients with low back pain.

CHAPTER 2

LITERATURE REVIEW

2.1 Prevalence of flat foot

2.1.1 Prevalence of Flat Foot Among Children

There was much literature and research showing that prevalence of flat foot deformity is strongly associated with age, gender, as well as physical appearance. As mentioned before, the flat foot deformity can develop during childhood, and it may also last throughout adulthood. Prevalence of flat foot deformity among children who aged from 5 to 13 years old are decreasing with age whereas male recorded higher risk than females. According to Chen et al. (2009), 20% of females and 35% of male reported having flat foot, respectively. According to the data given, the flat foot deformity was significant more prevalent among children who were overweight (31%) or obese (56%) than normal weight (27%). Compared to children with normal feet that bear weight, children with flatfeet experience a higher change in foot length and a lower foot height. According to Pfeiffer et al. (2006), the prevalence of flat foot among 3 to 6 years old populations was 44%. Same as the previous study, the prevalence

decreases with age. 3 years old children are reported 54% whereas there is only reported 24% in 6 years old children.

In short, concluding the articles above, the flat foot distribution among the children is more highly significant prevalence among overweight kids and males. Besides, the prevalent of flat foot decreases with the age increases.

2.1.2 Prevalence of Flat Foot Among Young Adults

There was a slight difference in the flat foot proportion between males and females among college and university students who aged between 18 to 25 years old. There were few studies were conducted among young adults with flat foot deformity. According to Kun-Chung Chen et al. (2011), the study shows that only bilateral flat foot was associated with age, weight, and gender whereas these factors are not influenced by the unilateral flat foot.

According to the findings from Ezema et al. (2014), there was reported the flat foot prevalence among young adults was 106 subjects over 474 (22.4%). Among them, the flexible flat foot recorded 87.7% whereas bilateral flat foot accounted for 91.5% among the populations. Besides, there was a study conducted among medical university students who aged between 17 to 23 years old. According to the research findings, it illustrated the prevalence of bilateral

flat foot with 11.6% whereas the unilateral flat foot with 3%. It was assessed through few methods which includes navicular drop (ND) test, arch index (AI), and foot posture index (FPI). Moreover, this study also proven that the prevalence of flat foot was highly associated with higher BMI populations and affected their quality of life (QOL) and functionality (Reddy & Kishve, 2021). Other than this, there was another research from Khadanga & Kumar (2022) which also conducted among the college students. According to the result, there was 20% of the college students who aged between 18 to 25 years old diagnosed with flat foot by using navicular drop test. Among them, it consists of 21.55% of male and 17.97% of female. Apart from that, there was a study done in Nigeria among young adults with flat foot. The result showed that the prevalence flat foot was 8.6% among 384 participants whereas the males have higher prevalence than females (Igbinedion et al., 2022). Apart from this, the findings from Gonzalez-Martin et al. (2017) showed the prevalent of flat foot among undergraduate students was 62.0%, assessing by the CSI method. Therefore, the results from Beheshti et al. (2018) also showed the prevalent of flat foot deformity was 74% among the 945 students.

In short, concluding the articles above, the flat foot distribution among young adults is more highly significant prevalence among male population. Besides, the percentages of bilateral flat foot were higher than unilateral flat foot.

2.2 Pathophysiology of flat foot

The severity and presence of flat foot deformity is determined by the medial longitudinal arch. In fact, the arising of flexible flat foot usually because of the ligamentous laxity whereas the adult-acquired flat foot is caused by posterior tibial tendon dysfunction. Besides, obesity, neuropathy, soft tissue injury, and bone injury are also considered as possible factors to develop posterior tibial tendon dysfunction. Moreover, bone deformities such as tarsal coalition, congenital vertical talus, or arthritis can also result in rigid flatfoot (Flatfoot - an Overview | ScienceDirect Topics, n.d.).

The medial longitudinal arch is considered as a relatively important factor in the flat foot condition. It is form by calcaneus, navicular, talus, three cuneiforms, and first, second, and third metatarsals whereas supported by plantar calcaneonavicular ligament, deltoid ligament, posterior tibial tendon, plantar aponeurosis, as well as flexor hallucis longus and brevis muscles. The major causes of acquired flat feet were found which include obesity, malfunction of the posterior tibial tendon, excessive strain of triceps surae, ligamentous laxity of plantar fascia and others supporting structures, tightness of Achilles tendon and calf muscles. Generally, rigid flat foot is relatively least, it often arises during childhood, but it also may happen at any time of life. It results from congenital vertical talus, accessory navicular bone, tarsal coalition, or other congenital hindfoot pathologies (Raj et al., 2020).

Flexible flat foot is known as the most prevalent and the prevalent type of flat foot. The flexible flat foot mostly found in childhood and some of them might persist to adulthood. In flexible flat foot populations, there was a thick fat pad on the plantar surface of newborn's feet that may last for several years. In fact, this type of flat foot usually involves hypermobility of the subtalar joint. Among the flat foot populations, the foot structure during stance phase was different from healthy individuals. During the first half of stance phase of the gait cycle, the tibia and talus internal bend while the subtalar joint evert outwards and the unlock the foot complex. Then, the tibia and talus external bend while the subtalar joint invert during the latter stage of the gait cycle and the foot is fully locked. The flexible flat foot is different from normal inversion during the latter part of the stance phase, and consequently lead to instability of foot. However, it causes the fatigue of ankle and leg muscles (Ueki et al., 2019).

2.3 Management of flat foot

As it is known as that it is a fact about flat foot might affect the balancing, supporting muscle fatigue and pain over the legs and feet, increase risk of injuries, postural problems, and others. Therefore, the proper interventions for flat foot able to improve their quality of life (QOL) instead of fully cured the conditions. Generally, asymptomatic flexible flat foot does not need to be treated unless the individuals experienced painful, discomfort, and interfere their daily living

activities. The current medical treatment of flat foot consists of corrective footwear and insole, ankle bracing and taping, foot muscles training, medications, and correction surgical interventions.

2.3.1 Foot orthotic and insoles

Foot orthotic also referral as corrective footwear which benefit in supporting the normal foot function and the proper foot alignment. Mainly, the foot orthotic intensify the sensory feedback from the medial aspect of foot and maintain the postural stability. According to Ueki et at. (2019), corrective footwear plays important roles in flat foot condition. Several medical professionals have claimed that employing corrective footwear, specially designed arch supports, or personalized orthoses can benefit the height of the foot arch both clinically and radiographically. There was research conducted regarding the treatment of Helfet heel seat or University of California Biomechanics Laboratory (UCBL) shoe insert, which showed 79% of clinical and radiographic improvement on these interventions (Bleck & Berzins, 1977). Furthermore, there was a study shown that the application of foot orthotic for two months had showed improvement the strength of abductor hallucis muscle (Jung et al., 2011). According to Raj et al. (2020), the findings showed the introduction of foot orthotics for foot pain secondary to purely flat foot or combination with leg, knee, and back pain.

2.3.2 Ankle Bracing and Taping

Therefore, the ankle bracing, and arch taping combined with medications are known as a temporary way to relief pain and prevent worsening symptoms in current clinical settings. Currently, there were few tapes can be used to support, reduce pain, induce foot muscles activation, and alternate the plantar pressure distribution. According to Kodithuwakku Arachchige et al. (2019), the non-elastic tape, such as Kinesiotape was showed more effective than elastic tape in flat foot management. Moreover, the ankle bracing is more prevalent to be used among acquired flat foot and effective for a limited period. The ankle bracing equips support and pain relief, especially over the foot arch. The mechanism is different from non-elastic tape as the non-elastic tape only work in pain relieving instead of repositioning the rearfoot posture.

2.3.3 Foot muscles training

Medial longitudinal arch (MLA) is supported by tibialis anterior muscles, tibialis posterior muscle, peroneus longus muscle, posterior tibial tendon, and the foot intrinsic muscles which includes abductor hallucis, flexor hallucis brevis, flexor digitorum brevis, and interosseous muscles. According to Kodithuwakku Arachchige et al. (2019), intrinsic foot muscles strengthening exercises were effective and benefits in improving plantar pressure distribution and pain relieving. Therefore, the intrinsic foot muscles strengthening also improve balance, decrease navicular drop and improve in arch height index. Furthermore, according to the

research done by Panichawit et al. (2015), the foot muscles training which include stretching and strengthening of gastrosoleus muscles, and intrinsic muscles for eight weeks, and three times in each week. The results showed significant improvement in strength of tibialis posterior and peroneus longus, as well as reduce the foot function score.

2.4 Complication of flat foot

There are many symptoms arise along with the flat foot deformity if the condition left untreated or getting worsen. Some of the flat foot individuals can also live with the condition with asymptomatic. The condition is differed from person to person. In fact, pes planus affected the alignment of lower limbs as well as trunk, especially during standing, walking, and running for a long period of time. The most identifiable symptoms of flat foot were pain and muscles fatigue (Flat Feet Pain Treatment & Symptoms, n.d.). As usual, the pain arises from hips, knees, ankles, as well as lower back whereas the inner side of feet and arches were more prone to muscles weakness. Furthermore, there was a series of issues arise due to presence of flat foot, include inflammation of soft tissue, lower extremities muscles weakness, joints pain, low back pain, plantar fasciitis, Achilles tendonitis, arthritis, and posterior tibial tendon dysfunction (PTTD). Apart from these, the flat foot deformity also affected the postural alignment, such as rolled-in ankles, genu valgum, excessive anterior pelvic tilt, abnormal gait pattern, shin splints, bunions, and hammer toes.

2.4.1 Poor Posture

The individuals with flat foot had greater risk of developing postural misalignment due to the impact of weak foot posture. The foot arch of the flat foot individuals tends to collapse against the ground and caused the shinbone and femur rotate medially. This abnormal posture placed more stress and load over the ankles, knees, hips, as well as lower back of the individuals. The poor posture that can be observed among flat foot population consist of the knees appearing bent medially, the pelvic tilt forward, and the curvature of lower back increased. The risk of postural misalignment increased when the load placed on the body increased. The poor posture can lead to muscles tightness, muscles weakness, and imbalance. If the condition left untreated, the posture misalignment getting worsen and affect the physical appearance of the individuals. Apart from this, it also results joint pain, arthritis, and increased risk of injured during physical activities (Orthotics, n.d.).

According to Veis et al. (2022), the researchers assessed the posture based on the few landmarks: head, thorax, backbone, hips, and shoulders among the flat foot individuals. The researcher found 22% of the participants had incorrect posture and one of the participants had very poor posture after evaluating the overall posture.

2.4.2 Excessive Anterior Pelvic Tilt

According to Vialle et al. (2005), the normal pelvic is slightly tilt forward during standing. According to the data given, the mean of the degrees of pelvic tilt was around 13° ± 6° when the individual in standing position. The flat foot affected the lower limbs structure as well as abnormally distribute the stress. Malalignment of the lower extremities brought on by hyperpronation can result in structural and functional issues when standing and ambulating. Khamis & Yizhar (2007) have discovered that there was a trend of increasing internal shank rotation, internal hip rotation, and anterior pelvic tilt among flat foot individuals. These results imply that forces operating on the foot can affect the alignment of the lower extremities up to the pelvic girdle. Kinematic chain reactions take place when the foot and pelvis are in contact. In comparison to normal participants, bilateral flexible second-degree flatfoot showed higher pelvic inclination, lumbar lordotic, and thoracic kyphotic angles (Abdel-Raoof et al., 2013).

According to Eldesoky & Abutaleb (2015), both unilateral and bilateral second degree flat foot significantly increased pelvic anteversion when compared to the healthy participants. However, compared to unilateral flat foot participants, bilateral flat foot subjects showed the higher prevalent to have higher levels of excessive anterior pelvic tilting degrees. Compared to participants with bilateral flat foot and healthy feet, those with unilateral flat foot experienced a considerable lateral pelvic tilt toward the affected side. According to the research from Abdel-Raoof et al. (2013), the pelvic inclination, lumbar lordotic, and

thoracic kyphotic angles were significantly higher among individuals with bilateral flexible second-degree flat foot than in healthy individuals.

Furthermore, there was a study shown that alternation of pelvic alignment by standing on the wedges at different angle caused foot hyperpronation, with 41% to 90% of the changes being attributed to the intervention. Additionally, a statistically significant increase in internal hip rotation, anterior pelvic tilt, and internal shank rotation was reported due to the foot hyperpronation. Besides, Hornestam et al. (2021) had discovered that the foot hyperpronation affected pelvic and hip motion. The pelvic inclined contralateral side and decreased range of motion (ROM) in frontal plane whereas the pelvic position reduced rotation and without significant changes on range of motion. The hip was more prone to internal rotation but without changes in range of motion. According to these results imply that forces operating on the foot can affect the alignment of the lower extremities up to the pelvic girdle. Kinematic chain reactions take place when the foot and pelvis are in contact.

2.4.3 Low Back Pain

Low back pain was a condition that the patient suffer dull ache, stabbing, or shooting pain over the lower back region. This condition may be chronic or acute. It was a common problem that affect quality of life, especially in sleeping (14.6%) and walking (12%). Low back pain has also been reported as a condition

that mostly contribute to the disability and postural condition. According to Vujcic et al. (2018), they reported prevalent of 75.8% of fourth year medical students were having low back pain, the female proportion was higher than male. Therefore, 12.4% of them were experienced chronic low back pain. Besides, there was a study conducted among health sciences undergraduate students who average aged 21.4±1.3 years old. There was reported 40.3% of them had problems with low back pain (Nor Azlin Mohd Nordin et al., 2014).

Furthermore, from the study showed by Almutairi et al. (2021), there was reported 65.9% prevalence of low back pain (LBP) associated with flat feet. It was reported 51.6% developed acute low back pain (ALBP) whereas 48.4% suffered from chronic low back pain (CLBP). ALBP and CLBP were more likely to occur in people with flat feet by 3.28 and 4.5 times, respectively. Following stratification, all subjects with flat feet showed substantially greater ALBP and CLBP compared to their counter groups. According to Kosashvili et al. (2008), anterior knee pain and intermittent low back pain were about twice as common in those with moderate and severe pes planus, but not significantly more common in people with mild pes planus.

Apart from this, the incidences of low back pain also highly associated with the pelvic orientation. According to Król et al. (2017), this study was done among university female students who aged between 20 to 26 years old. The

result of this study discovered that the relationship between excessive anterior pelvic tilt and low back pain was significantly associated (P=0.049). Besides, there was also a study showed that the low back pain patients reported greater pelvic tilt angle than the healthy people. According to the result, it showed that those excessive anterior pelvic tilt individuals had contribute more risk of developing low back pain (Lim et al., 2013).

2.4.4 Sacroiliac joint dysfunction

Sacroiliac joint (SIJ) is considered as a bilateral diarthrodial synovial joint which articulates the sacrum and iliac bones. It acted as a connection between pelvis and spine. Sacroiliac joint dysfunction is considered as the pain presence over sacroiliac joint due to abnormal movement or malalignment of the joints. The sacroiliac joints dysfunction may lead to low back pain, pain over the legs, inflammation of the joints. Sacroiliac joint syndrome and low back pain are difficult to differentiate and identified. There was around 90% of patients experienced low back pain whereas only 10% to 25% of patients feel pain over the SIJ region (Sacroiliac Joint Syndrome, n.d.). According to Yeomans (2013), there was 15% to 30% of low back pain cases were due to the sacroiliac joints dysfunction. Besides, the sacroiliac joints dysfunction also similar with the lumbar disc herniation, which also known as sciatica. Both conditions were suffered with radiating leg pain and the patients were difficult to identify.

According to Dr. Bill Pohlen, excessive pronation of foot causes a series of reactions that impact on the rest of body alignment and alter the lower limbs mechanics as well as limb length. Standing with different limb length results in an uneven pelvis alignment then leads to postural shifts. The degenerative changes will be observed significantly in hip joints, pelvis, and spine. In addition, walking with a hyperpronated foot will cause excessive internal rotation of hip whereas the rotational forces are transmitted to the pelvis, especially the sacroiliac joint (Systems, 2017). The poor posture and the stress overload on joints affect the sacroiliac joints. According to Falk Brekke et al., the excessive anterior pelvic tilt may lead to several clinical disorder or pathology. It considers as a causing factor of femoracetabular impingement, low back pain, and sacroiliac joints dysfunction. According to the findings from Baruah et al. (2013), the authors found the people with sacroiliac joints pain had poor postural stability compared to the healthy individuals. According to Lowe (2014), the anterior pelvic tilt had altered the stress and force placed at the sacroiliac joints. This considers as a frequent cause factors in developing pain and dysfunction of sacroiliac joints. Apart from this, the findings from Fatemeh & Asghar (2008) also showed the prevalence of sacroiliac joint dysfunction (49.3%) with flat foot was higher than normal health subjects.

2.5 Assessment of Flat Foot

Overall, there was not any standard evaluation methodology for flat foot, and the condition was classified under many different aspects. Mostly, the assessment focuses on the foot arch, posture, and flexibility. The common assessment tools for flat foot diagnosing are radiography, footprints, as well as visual observation whereas radiography is the most accurate tool and consider as the gold standard measurement among them.

2.5.1 Radiography Method

According to Dr. Colin Tidy (2022), the standing foot X-ray is one of the useful methods to determine the degree of deformity. It is gold standard measurement for the flat foot deformity as the imaging can show the structure in a clearer picture for reference. The longitudinal arch and talonavicular joint can be observed through standing lateral view. The degree of heel valgus which is talocalcaneal angle can be determined through standing anteroposterior (AP) view of X-ray. Besides, soft tissues can be assessed through magnetic resonance imaging (MRI) or ultrasound methods, such as posterior tibial tendon and spring ligament and interosseous ligament. Besides, the generalized joint laxity can be assessed through Beighton Score.

2.5.2 Footprints Method

Currently, footprint assessments are widely assessed in clinical practices as it is costless and convenient. Mainly, the footprints of the foot arch determine the foot shape. It can be classified as normal, flat, intermediate, or high arch. According to few research that have been done, there are few protocols suitable and reliable used in flat foot assessments, such as Clarke's Angle (CA), Foot Posture Index-6 (FPI-6), Chippaux-Smirak index (CSI) and the navicular drop test (NDT). According to Mohd Shariff et al. (2017), the researcher determined the foot arch by using five different footprints methods which including Clarke's angle, Chippaux-Smirax index, Staheli index, Arch index, and Harris-imprint index. Women who aged between 20 to 60 were joined in this study. This study showed that around two third of the participants had different foot arches between both feet when measured by the Harris-imprint index. Moreover, the prevalence of flat foot was higher in overweight (51%) and obese (18%) people.

. The angle between the medial margin of the footprint's tangent and the line connecting the furthest perpendicular distance from the medial border of the foot and the point at which the medial tangent crosses the margin of the front foot was known as the Clarke angle (Pauk et al., 2014). According to Hegazy et al. (2021), both techniques are valid for diagnosing flat foot. From the experiment results, Clarke's angle had higher intra-rater reliability (ICC=0.99), sensitivity (ICC=0.96), and specificity (98%) than FPI-6. Besides, the navicular drops test (NDT) was first published by Brody in 1982, which is known as one of the

clinical tests for evaluating the medial longitudinal arch. The test is known as a reliable, accurate test for determining medial longitudinal arch height rather than using footprint parameters. Compared to footprint assessment which required ink and the data are difficult to interpret and inaccuracy of measurement (Zuil-Escobar et al., 2018). According to Gonzalez-Martin et al. (2017), the results of this study shown the weakness of the Clarke's angle test which has a limited sensitivity in screening flat foot when compared to the Chippaux-Smirak index.

The Chippaux-Smirak index method identified higher prevalence of flat feet than the Clarke's angle. From the result of the research, the Chippaux-Smirak index act as the reference tool for flat foot diagnosing tool as its sensitivity is 51.1%, specificity is 75.0%, with a positive predictive value of 76.8% and a negative predictive value of 48.7%. There were some researcher proofs that the Chippaux-Smirak index own a better predictive capacity for diagnosing flat foot than other methods. Besides, there were few of the professionals also recommend that the Chippaux-Smirax index was a standard screening tool for flat foot diagnosing among preschool-age children. The Chippaux-Smirax index was calculated based on two prominence length on the footprints which are the widest and the narrowest length. The CSI was calculated according to the formula, CSI = (h/f) x 100%. The 'h' indicated the narrowest midfoot width whereas the 'f' indicated the greatest forefoot width. According to Tomankova et al. (2015), there was a guideline to determine the severity of the flat foot and normal foot based on the CSI value. Both flat foot and normal foot were categorized in three degrees

based on the percentages of the CSI value. The first degree of flat foot was between 45.1% to 50.0%; the second degree of flat foot was between 50.1% to 60.0%; the third degree of flat foot was between 60.1% to 100.0%. The first degree of normal foot was between 0.1% to 25.0%; the second degree of normal foot was between 25.1% to 40.0%; the third degree of normal foot was between 40.1% to 45.0%. Lastly, the absence of the middle part of foot, indicating high foot.

2.5.3 Foot posture index (FPI) method

Furthermore, the FPI-6 is an assessment tool that used to determine the foot posture based on six observations and palpation. The six criteria for the FPI consist of talar head palpation, supra and infra malleoli curvature, calcaneal frontal plane position, prominence in region of TNJ, congruence of medial longitudinal arch, and the abduction and adduction of forefoot on rearfoot. During the assessment, the patient needs to stand with double limb support, arms by side, and looking forward. However, the FPI-6 was commonly used to assess foot posture in people who associated with low back pain. Some authors also showed that, the FPI-6 was a simple and reliable assessment tool for assessing children foot (Morrison & Ferrari, 2009).

2.5.4 Navicular drop (ND) Test

Apart from this, the navicular drop (ND) test is a reliable clinical assessment tool to evaluate flat foot. This test consists of the excellent interrater in both healthy and flat foot individuals. This test was assessed through the measurement of the distance (in millimeters) between the height of navicular tuberosity during neutral alignment and relaxed position. Therefore, the medical practitioner who performed the ND test should be able and experience to identify and palpate the subtalar joint and place it in a neutral position precisely. Hence, this test is more suitable for the trained physiotherapists or other experienced medical practitioners (Zuil-Escobar et al., 2018).

2.6 Pelvic tilt assessment

The term of pelvic tilt refers to the position or movement of the pelvis in the sagittal plane. The degree of pelvic tilt was known as the angle produced by a horizontal line and a line splitting the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) in the sagittal plane. It can be assessed in a static, active, or functional manner. Besides, visual observation, the hand-held inclinometer, and the caliper-based inclinometer are the most frequently mentioned methods of assessing degree of pelvic tilt in the outpatient rehabilitation setting.

2.6.1 Caliper-based Pelvic Inclinometer

Among the assessment methods, the caliper-based pelvic inclinometer shows high reliability and validity than others in assessing pelvic tilting (Suits, 2021). Besides, the findings from Beardsley et al. (2016), the digital pelvic inclinometer also showed good inter-rater reliability (ICC -0.81 – 0.88). Besides, according to Hagins et al. (1998), intertester reliability was high for sagittal plane measurements (0.89) but low for frontal plane measures (0.65), according to intraclass correlation coefficients (ICC). Intratester reliability was high for both frontal (0.84) and sagittal plane measures (0.98).

The PALM palpation meters are caliper-inclinometer instrument. It also widely be used in measuring the degree of pelvic tilt. The angle created by connecting the ASIS and PSIS with a horizontal line was used to calculate the standing pelvic tilt. In the sagittal plane, anterior innominate tilts were described using positive degrees, and posterior tilts were described using negative degrees. According to Herrington (2011), the caliper-based pelvic inclinometer, PALM palpation meter, showed good intra-rater reliability (ICC = 0.87; SEM = 1.1) among 120 young adults who average aged 23.8 $\pm$ 2.1 years old.

2.6.2 G-walk BTS G-SENSOR

G-walk BTS G-SENSOR smart analyzer was a wireless device to assess the pelvic symmetry, such as pelvic rotation, pelvic tilt, and pelvic obliquity

during locomotion. According to Gieysztor et al. (2020), the pelvis symmetry gait was assessed through BTS G-SENSOR, which has an inter-instrument correlation coefficient between 0.90 and 0.99. The subjects were requested to walk with barefoot for 5 meters. The sensor which is located at the lumbar region will analyze the pelvic symmetry.

2.6.3 Visual Assessment

The visual assessment is commonly be used in physical examination of anterior pelvic tilt since it is costless and convenience to be performed. The assessor directly observed the posture and orientation of the patients based on postural grid and define the decision. Based on the findings from Fedorak et al. (2003), the author found the fair intra-rater and poor inter-rater reliability for the visual assessment in assessing the lumbar lordosis. Besides, the assessor also may identify the degree of pelvic tilt by using the photogrammetric method. The photography taken should be involved in various angle and direction to ensure the accuracy of the findings. According to Bonifácio et al. (2013), the subjects will take photographs from anterior, lateral, and posterior aspects. Then, the photographs were analyzed by Alcimage software. The intra-observer correlation coefficient ranged from 0.9994 to 0.9760, and the inter-observer correlation coefficient ranged from 0.9511 to 0.9941. The longitudinal changes in pelvic alignment can be assessed through sagittal perspective where the diagnosis of pelvic asymmetries through frontal view was limited.

2.6.4 Smartphone application and software

Besides, according to the systematic review from Camelo et al., the postural assessment software (SAPO) was widely used in research and studies compared to other applications. From Ferreira et al. (2010)., the postural assessment software is considered as an accurate measuring tool for postural assessment. The inter-rater reliability of variables was 41% whereas 44.5% of measurements were excellent, 23.5% were very good, and 12.4% were acceptable in intra-reliability. According to the findings from Koumantakis et al. (2016), the application which called "iHandy Level" was applied to 183 young adults who average aged 26.1 $\pm$ 10.04 years old to measure the pelvic position in standing position. The result showed excellent intra-rater reliability (ICC =0.97; SEM= 1.61).

2.6.5 Tri-goniometric Method

In addition, the tri-goniometric method is considered as a costless, safe, and convenient technique that can be used in measuring pelvic tilt angle. According to Thiruvarangan et al. (2017), this method can be used in quantitatively document the pelvic tilt measurement. The researcher had done 12 trials of measurement on each participant to minimize the error information. This study was conducted with 49 samples and resulted in 0.91 of validity coefficients, 0.82 of reliability coefficients of standing pelvic tilt angle measurement. The

degree of pelvic tilted will be measured through the formula: Sin θ = (A-B)/C; A indicated distances from PSIS to ground, B indicated distances from ASIS to ground, C indicated distance from ASIS to PSIS. According to Le Huec et al. (2011), the average pelvic tilt angle is 13° ± 6° when the individual in standing position.

2.7 Sacroiliac joint mobility assessment

The sacroiliac joint (SIJ) dysfunction affects the distribution load to the lower extremities in order to impact postural balance due to its connection with the static center of gravity and postural reorganization. Combination of a positive stork test and other sacroiliac mobility test indicate the impairment of sacroiliac joint mobility. Gillet test, also known as Stork test, which is an assessment tool to assess the sacroiliac joint through palpation of posterior superior iliac spine (PSIS) and base of sacrum. This test was assessed in both stance and swing phase. The examiner should compare both joints for the quality and the amplitude of the movement (Stork Test, n.d.). According to study from Guimarães et al. (2021), the sacroiliac joints mobility was assessed through functional kinetic evaluation which consisting of the standing flexion test (SFT), Downing test, and Gillet test. Sacroiliac joint assessment required several tests because they are subjective.

2.7.1 Shimpi Prone SIJ Test

According to Shimpi et al., the "Shimpi Prone SIJ test" was a latest clinical test for assessing the sacroiliac joints dysfunction. The findings from the study above showed reliability analysis revealed a strong correlation by the ICC ($r>0.8$) and a significant agreement by the kappa coefficient ($k>0.6$), both at 95 percent confidence intervals. It shows good validity (79.9%), sensitivity (82%) and specificity (77%) compared to the Gillet test and Gaenslen test. This test was assessed in prone lying position. The assessor put the palm above the anatomical landmark, the anterior superior iliac spine (ASIS) of the patients. Then, the patients were requested to extend their hip with knee extended.

Moreover, this new clinical test is more suitable in applying among various population, even for the ectomorphic patients or the patients with poor balancing. During this test, the patient requires to prone lying on a bed. This position was comfortable and does not show any problems for instability or balance concerns for the patients. The patients also no need to expose the lower back and buttock region which can be more acceptable among different cultures.

In fact, sacroiliac joints are a translatoric glide. The mobility of the SIJ depends on the traction or compression of the joint surfaces. In this test, the patients were requested to perform hip extension while the gluteus maximus and hamstring muscles are contracted; and the multifidus and erector spinae muscles

are stabilizing the vertebrae column to allow the hip extensors acts on the pelvis. Besides, the glutes muscles are connected to the thoracolumbar fascia. When the patients are performing hip extension, the back muscles will dynamically stabilizing the excessive movement of vertebrae column. Therefore, the compressive and translatoric forces will act across the sacroiliac joints and this might provoke the pain over the joint's region.

In addition, the mobility in this assessment consists of the action at lumbosacral junction and allows hip extension at acetabulofemoral joint by causing a SIJ counter-nutation motion. This assessment is considered positive when the patient reproduces normal pain meanwhile the femoral nerve may be stressed. Therefore, the normal response in this test is the patients perform the hip extension while initiate the extension of the lower lumbar and the lumbosacral regions, and accompanied with the forward rotation of pelvis and the hip extension.

2.8 Conclusion

In conclusion, according to the literature review above that have summarized the prevalence, pathophysiology, assessment, management, as well as complications of flat foot and the various of screening tools for anterior pelvic tilt and sacroiliac joint dysfunction. Flat foot is a common observed foot deformity condition can be developed during childhood or throughout adulthood.

Flexible flat foot was known as a most prevalent types of flat foot. According to the study above, the findings show around 20% of undergraduate students who aged between 18 to 25 years old were diagnosed as flat foot deformity. Among them, the flexible typed of flat foot is recorded with more percentages and proportion. The males and overweight individuals had greater chance to develop flat foot.

As mentioned before, the flat foot deformity alters the foot structure and posture. Alternation of foot structure may lead to structural deformities, pain, inflammation. From the study above, the findings showed that the flat foot individuals have more tendency to develop anterior pelvic tilt than normal healthy people. Thus, there was also a study found that there was 65.9% of flat foot people suffering acute and chronic low back pain. Hence, around 90% of the low back pain patients have sacroiliac joint problem, whereas there is around half percentages (49.3%) of the flat foot patients are diagnosed with sacroiliac joint dysfunction.

Currently, there is available many assessment and screening tools for diagnosing flat foot, anterior pelvic tilt, and sacroiliac joint mobility. There are few assessment protocols can be used in screening flat foot. According to the study, the foot X-rays was known as the gold standard measurement, but it was costly. Besides, CSI is more effective and reliable assessment tool for diagnosing

flat foot. It has higher validity and reliability rate compared with other methods. For the anterior pelvic tilt screening, the most accurate tool is radiography method while it's not applicable to be used in this study. The trigonometry method which mentioned above is cheaper, applicable, reliable, and easier method that can be performed in this study settings. Besides, the mobility of the sacroiliac joints is very minor. So, it's difficult to measure and assess it with single test. According to the study have done before, there is a new clinical test, which called Shimpi prone SIJ test. This test was applicable to various population and easy to perform in this study.

CHAPTER 3

MATERIALS AND METHODS

3.0 Introduction

In this chapter, the study design, study setting, study population, sample size, sampling method, inclusion and exclusion, instruments and equipment, procedure, statistical analysis, and ethical approval will be presented.

3.1 Study Design

A correlational study was conducted in this study. The correlational study was used to define the relationship between the flat foot with anterior pelvic tilt and sacroiliac joints dysfunction by using a variety of outcome measures. This type of study was suitable for investigating the relationships between variables without controlling or manipulating them. The data were collected by building a screening booth.

3.2 Study Settings

This study is carried out at KA102, Physiotherapy Exercise Laboratory which located at Universiti Tunku Abdul Rahman, Sungai Long campus. The data collection of this study lasted for 2 weeks, which started from 7 November 2022 to 25 November 2022.

3.3 Study Population

Undergraduate students who aged between 18 to 25 years old and currently enrolled in any undergraduate programmes in Universiti Tunku Abdul Rahman, Sungai Long Campus. The young adults who identified with either unilateral or bilateral flat foot by the CSI method and without undergo any flat foot corrective surgery. These population was eligible to include in the present study.

3.4 Inclusion Criteria

1. Undergraduate students in Universiti Tunku Abdul Rahman, Sungai Long campus who aged between 18 to 25 years old.
2. Diagnosed with unilateral or bilateral flat foot
3. Female and male

3.5 Exclusion criteria

1. Spinal deformity, such as scoliosis
2. Corrective surgery for flat foot deformity

3.6 Sample size

The sample size of this study was calculated according to the Krejcie and Morgan (1970) table.

The formula of the Krejcie and Morgan used for sample size calculation is shown as below:

$$\mathbf{n} = \frac{\chi 2\, NP(1-P)}{d^2(N-1) + \chi 2\, P(1-P)}$$

Based on the table above, the n represent as required sample size, X^2 represent as Chi – square for the specified confidence level ar 1 degree of freedom, N represent as population size, P represent as population proption, and d represent as desired margin of error.

The population size of this study was 7104 which indicated the total number of undergraduate students in UTAR, Sungai Long Campus. Therefore, N was set as 7104, P was set as 0.5, d was set as 0.05.

According to the formula above, the required sample size calculated was 364 undergraduate students. Besides, there will be adding 10% of the attrition rate into the total sample sizes to prevent drop out, so the finalized sample size is 401. Thus, at least 401 young adults will be recruited in this study.

3.7 Sampling method

The convenience sampling method which is a non-probability sampling method was used in this study. The undergraduate students in Universiti Tunku Abdul Rahman, Sungai Long campus who were easy to reach and fulfil the inclusion criteria were recruited in this study.

3.8 Instruments and equipment

The instruments and equipment that were used in the present study included a stadiometer, foot ink, blank papers, a caliper, a measuring tape, labelled stickers, and a medical plinth.

3.8.1 Stadiometer

Figure 3.1: SECA Stadiometer (Mod 220).

A SECA stadiometer (Mod 220) that was shown in Figure 3.1 was used in the present study. It was used to measure the height and weight of the participants. The results obtained were accurate to one decimal.

3.8.2 Foot ink and blank papers

Figure 3.2: BUNCHO Poster Colors

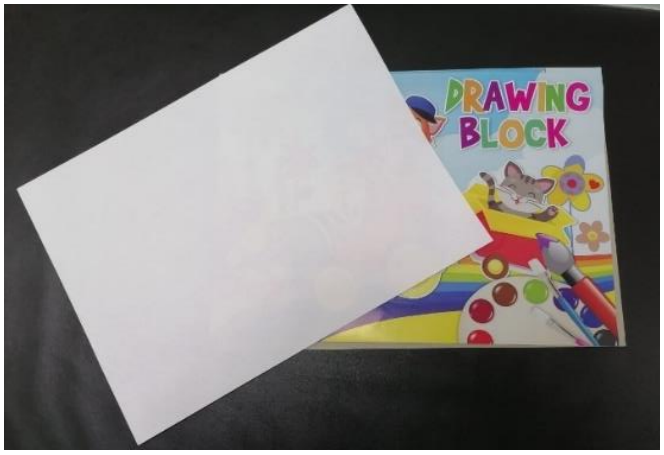

Figure 3.3: A3 Blank Papers

Figure 3.4: Foot Ink Basin (Left) and Cleaning Basin with Clean Water (Right)

There BUNCHO poster colors which showed at Figure 3.2 were used to collect the footprints of the participants. There were 12 poster colors in total were used in this study. The assessor mixed the poster colors with a little amount of water in a rectangular foot ink basin which provided as shown in Figure 3.4. The foot ink basin was used to collect the footprints from the participants. Besides, there was also provided a basin with clean water which located beside the foot ink basin, for cleaning their feet after immersed into the inked basin as shown at Figure 3.4. After that, the participants printed their footprints on the blank A3 (297 x 420mm) provided as shown at Figure 3.3.

3.8.3 Outsider Caliper, Measuring Tape, and Labelled Stickers

Figure 3.5: An 8’ Outsider Caliper

Figure 3.6: A 5.0 m Measuring Tape

Figure 3.7: A White Masking Tape Labelled Sticker

A white masking tape with the sized 25mm x 50m that shown in Figure 3.7 was used to label the anatomical landmarks after palpation. An 8 inches outsider caliper which showed at Figure 3.5 and a measuring tape which maximum length with 5.0 meter and width approximately 1.7 centimeter as shown at Figure 3.6 were used in this study for measuring the distances between PSIS and ASIS, distances between ASIS and ground, and the distances between PSIS and ground. These instruments were used to take the measurement of pelvic tilt angle degree.

3.8.4 Medical Plinth

Figure 3.8: Medical plinth

A medical plinth which showed at Figure 3.8 was used in this study. It was used to position the participants in prone lying position for the Shimpi Prone SIJ test.

3.9 Procedure

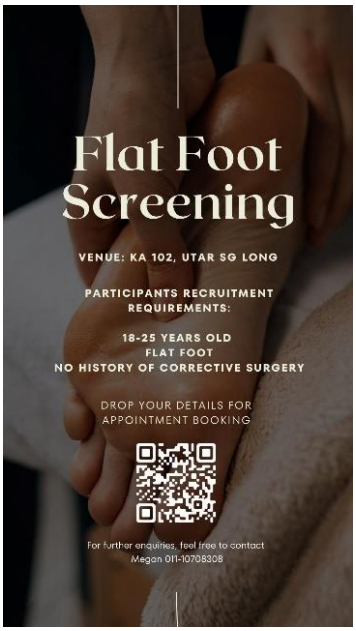

Figure 3.9: Poster of Participants Recruitment

After obtained the ethical approval from UTAR Scientific and Ethical Review Committee (SERC), the process of data collection began from 7 November 2022. Mainly, the recruitment of participants by spreading the poster (Figure 3.9) through social media and friends. The participants registered through the QR code which given in the poster and fill in their personal details and the availability time which easy for the assessor to reach them. Then, all the participants were be added into a WhatsApp group. The purpose of adding them into the group was easier to make the announcement and reminders regarding the venue and timeslot of the screening assessment. The participants who fulfil the inclusion criteria came to the KA102, Physiotherapy Exercise Laboratory, Universiti Tunku Abdul Rahman, Sungai Long Campus according to their availability time for their screening sessions.

Before the assessment started, there was a general briefing session regarding the procedure and the objective of this study to the participants. The briefing session allow the participants to clear their doubts and ensuring that they meet the eligibility criteria. Before the assessment, all participants were informed to sign the consent form (attached as Appendix 3), personal data protection statement (attached as Appendix 2), as well as fill in the demographic data (attached as Appendix 4) and data collection form (attached as Appendix 5). None of the participant had any spinal deformity, injury and neuromuscular disorder at the time of assessment.

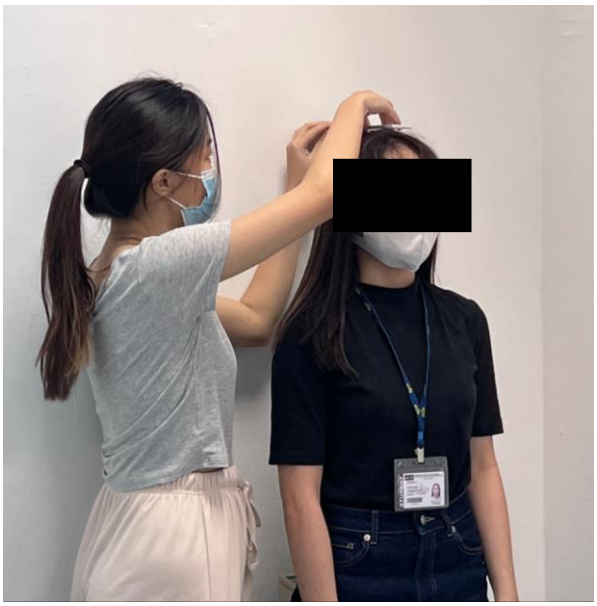

Figure 3.10: Height and Weight Measurements by Stadiometer

After that, the participants were instructed to the height and weight measurements station prior to the assessment. In this station, the assessor measure their weight and height and their weight, height, and BMI values need to be recorded in the data collection form. The participants were instructed to measure their height and weight by using the stadiometer as shown at Figure 3.10. Before these measurements, the participants were requested to put off the shoes, socks and they were requested to put off all of the objects from their pockets, as well as put off their watches and jewelries Next, they were instructed to stand erect on the stadiometer, weight bearing equally on both legs and looking forward. The height scale was adjusted to their height level to obtain their height. The assessor obtained the height and weight readings from the stadiometer and recorded their results into the data collection form (attached as Appendix 5) for documentation.

Figure 3.11: Participant immersed her feet into the foot ink basin.

After obtaining the height, weight, and BMI values of the participants, they were allowed to proceed to the first station. The first station was the flat foot screening which assessed through the CSI method. Prior to the measurement, the participants were requested to put off their footwear and socks. Besides, the assessor needs to make sure that there is not any open wounds presence over the feet and ankle area before they immersed their feet into the rectangular foot ink basin (Figure 3.11). After that, the participants were instructed to immerse their both feet into the rectangular foot ink basin and sustained for few seconds. This can make sure their feet were fully inked by the poster color which as shown at Figure 3.9.3.

Figure 3.12: Participant printed her footprints on a blank paper.

Figure 3.13: An Example Footprint of the Participant.

After that, the participants were instructed to stand on a blank A3 paper provided, with weight bearing equally on both legs (Figure 3.12). The participants need to sustain on the paper for few seconds to ensure the footprints was fully printed on the paper and ensure the picture is clear for calculation. The footprints should be clear and totally print on the blank paper given otherwise they need to redo the footprints for a more accurate measurement. The Figure 3.13 above shows an example footprint from a participant. The footprint was printed with a clear border and didn't exceed from the blank paper given which enable for the CSI value calculation. After that, the participants washed their feet with the clean water that provided in the cleaning basin which was located beside the rectangular foot ink basin. Then, their footprints were set aside to dry the foot ink for the CSI value calculation.

Their foot alignment can be determined by the characteristics of the footprints. According to the CSI formula given, the footprints of each participant was calculated as the foot width at the narrowest point divided by that at the widest point times 100%. The participants with CSI scoring greater than 45.0% on either one feet were considered to have flat foot. These participants were recruited in this study and proceed to the remaining stations.

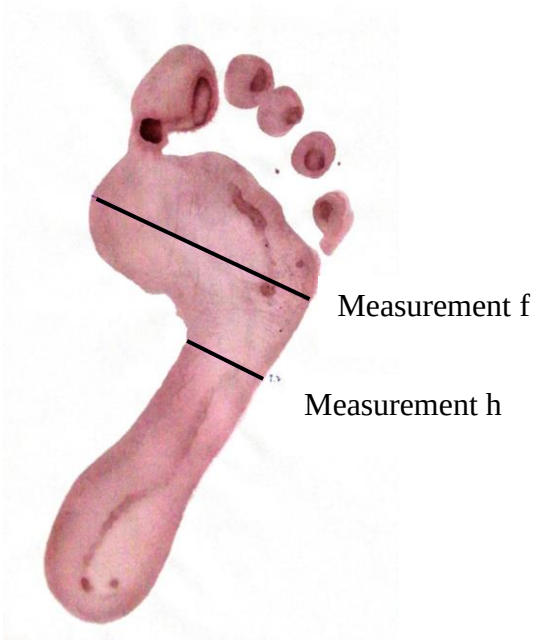

Figure 3.14: Calculation of Chippaux-Smirax Index Value.

The CSI value was calculated according to the formula: CSI (%) = (h/f) x 100. The calculation of CSI is considered as the ratio of the widest part and the narrowest part of the midfoot and multiplying the ratio by 100 which as shown at

Figure 3.14. The normal range of the CSI value is from 0.1 to 45.0%, while the value is higher than 45.1% it is considered that the individual has diagnosed as flat foot deformity. Moreover, the absence of a midfoot is considered a high-arched foot. The participants who scored more than 45.1% were eligible proceed to the next station and them were categorized based on the degree of severity. The other participants who scored below the score were excluded from this study.

Figure 3.15: Palpation of Anatomical Landmarks (PSIS)

The second station was the measurement of the degree of pelvic tilt. Before the assessment, the participants were requested to put off their footwear and they need to stand with barefoot. They were instructed to stand erect with both legs equally weight bearing, crossed their both hands on their chest and looking forward. The assessor took the measurements according to the anatomical landmarks: anterior superior iliac spine (ASIS) and posterior superior iliac spine

(PSIS). These anatomical landmarks were labelled by the white masking tape after the palpation as shown at Figure 3.15.

Figure 3.16: Measurement of the distance between ASIS and ground.

Figure 3.17: Measurement of the distance between ASIS and PSIS.

The assessor took three measurements which includes, (A) the distance between PSIS and ground, (B) the distance between ASIS and ground, and (C) the distance between ASIS and PSIS. The caliper was used to measure the distance between ASIS and PSIS (as shown at Figure 3.17) whereas the measuring tape was used to measure the distance between PSIS and ground and the distance between ASIS and ground (as shown at Figure 3.16). All of the measurements will be done at least 3 trials to minimize the data collection error.

The degree of pelvic tilt was calculated through the tri-goniometric method. The tri-goniometric formula of the degree of pelvic tilt was Sin□=(A-B)/C. After that, the average of the three measurement results considers as their degree of pelvic tilt, and the value compared to the normal range value.

According to Le Huec et al. (2011), the average of normal pelvic tilt angle is 13° ± 6° when the individuals are in standing position. Therefore, the participants whose pelvic tilt angle was greater than 19 degrees was considered as anterior pelvic tilt.

After that, the participants proceed to the final station. The third station was the Shimpi Prone SIJ test which used to assess the function of the sacroiliac joints. The participants were instructed to put off their shoes and prone lying on the medical plinth provided.

Figure 3.18: Procedure of Shimpi Prone SIJ test

After positioned the participants in prone lying position, the assessor placed the palm below the anatomical landmark, anterior superior iliac spine

(ASIS) of the participants as shown at Figure 3.18. Then, the participants were instructed to extend their hip with knee extended around 15 degrees to off their foot from the medical plinth. This test was done bilaterally, and assessor compared the movement from both sacroiliac joints to define the results. The ASIS depressed more on the palm of the assessor without pain or discomfort present over the sacroiliac joint region indicated normal and negative signs of this test. The positive sign of the test considered as the ASIS lifted off from the assessor's palm and presence of concurrently and familiar pain and discomfort over the sacroiliac joint region (Shimpi et al., 2018).

3.8 Statistical Analysis

The data collected in this study were computed and analyzed by using IBM Statistical Package for the Social Science (SPSS) version 26 software and Microsoft Excel to produce study findings. The data will be coded by using Microsoft Excel. The demographic data such as age, gender, and BMI value were analyzed through descriptive analysis to provide the frequency and percentage of the variables. Therefore, the correlation of flat foot with anterior pelvic tilt and sacroiliac joint dysfunction among young adults were analyzed through the Spearman correlation test.

3.9 Ethical Approval

The study was subjected to the ethical approval from UTAR Scientific and Ethical Review Committee (SERC) with the series number of U/SERC/224/2022. An ethical approval letter was provided after the approval, and it was attached in Appendix 1. The personal data protection statement and the informed consent form containing the introduction of the research was also attached in Appendix 2 and Appendix 3 respectively. All of the participants were notified that their information and data were kept confidential at all times and their participation in the study should be completely voluntary. Hence, the participants preserved the right to withdraw from the study at any time and the researcher has no authority to reject their withdrawal.

CHAPTER 4

RESULTS

4.0 Introduction

In this chapter, the findings and statistical analysis of this study will be presented.

4.1 Demographic Data of the Participants

The researcher had successfully recruited 176 participants for this study through physical recruitment and social media such as WhatsApp, Instagram, and WeChat. However, there is only 98 of the participants fulfil the inclusion criteria that mentioned at Chapter 3. There was 17 of them were excluded from this study due to spinal deformity whereas there is no one of them were be excluded due to the corrective surgery of flat foot. Besides, there was 61 of them were found with normal foot arch and they were excluded from this study. Hence, the data of these 98 participants with flat foot deformity were coded by using the Microsoft Excel and analysed by using the SPSS 26.0 version software.

Table 4.1: Descriptive data of the Participants.

	N (%)	Mean ± SD
N	98 (100.0%)	
Age		20.33±1.41
18	13 (13.3%)	
19	11 (11.2%)	
20	28 (28.6%)	
21	31 (31.6%)	
22	10 (10.2%)	
23	3 (3.1%)	
24	1 (1.0%)	
25	1 (1.0%)	
Weight (kg)		61.69 ± 14.67
Height (m)		1.64 ± 0.89
Gender		
Male	42 (42.9%)	
Female	56 (57.1%)	
BMI (kg/m^2)		22.77 ± 4.44
BMI Category		
Normal	75 (76.5%)	
Obese and Overweight	23 (23.5%)	
Awareness of Flat Foot		
Yes	23 (23.5%)	
No	75 (76.5%)	
Flat Foot		
Unilateral	30 (30.6%)	

Bilateral	68 (69.4%)	
CSI (%)		
Left foot		59.76 ±14.95
Right foot		55.39 ± 13.33
Pelvic tilt		
Normal	69 (70.4%)	
Anterior pelvic tilt	29 (29.6%)	
SIJ		
Normal	49 (50.0%)	
Dysfunction	49 (50.0%)	

Note: N = total number of participants, SD = standard deviation, BMI = Body Mass Index, CSI = Chippaux-Smirax Index; SIJ = Sacroiliac Joints.

Table 4.1 above shows the frequency and percentages for the age, gender, BMI category, and the associated factors of the participants. The mean and the standard deviation of the BMI value, and CSI score of the participants also presented at the table above.

According to the Table 4.1, the average age of the participants was 20.33 ± 1.41 years old. The average height and weight of the participants were 1.64 ± 0.89 m and 61.69 ± 14.67 kg respectively. The average BMI values of the participants was 22.77 ± 4.44 kg/m^2. Among all of the participants, the average CSI score for the left foot was 59.76 ± 14.95 % whereas the average CSI score for the right foot was 55.39 ± 13.33 %.

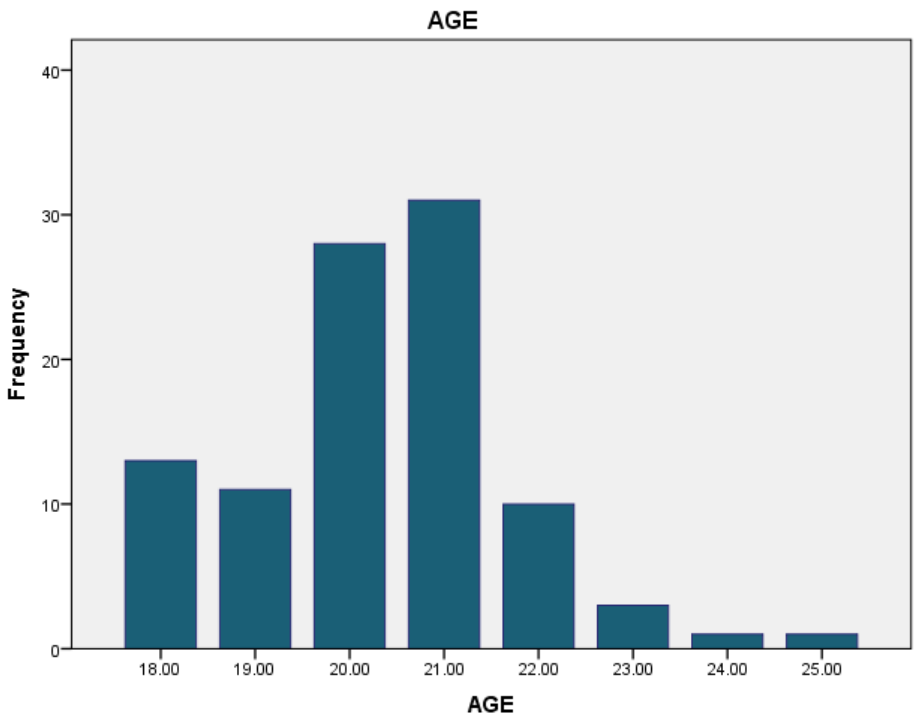

Figure 4.1: Distribution for Age of the Participants

According to the Figure 4.1 above, the bar chart shows the age distribution for both males and females' undergraduate students in UTAR with unilateral and bilateral flat foot who involved in this study. The majority of the participants were from 21 years old undergraduate students. It reported as 31.6% with the frequency 31 out of 98 participants. There are 28 out of 98 participants who aged 20 years old, comprising 28.6% which is considered as the second highest proportion among the total participants. The third highest aged group were from 18 years old, it consists of 13.3% with frequency 13 out of 98 participants. Both participants

who aged 24 and 25 years old only consists of one participant, both contributing 1% of the total participants. There are 11 participants aged 19 years old and 10 participants aged 22 years old, making up 11.2% and 10.2% respectively. There are only three participants aged 23 years old and making up 3.1% of the total participants.

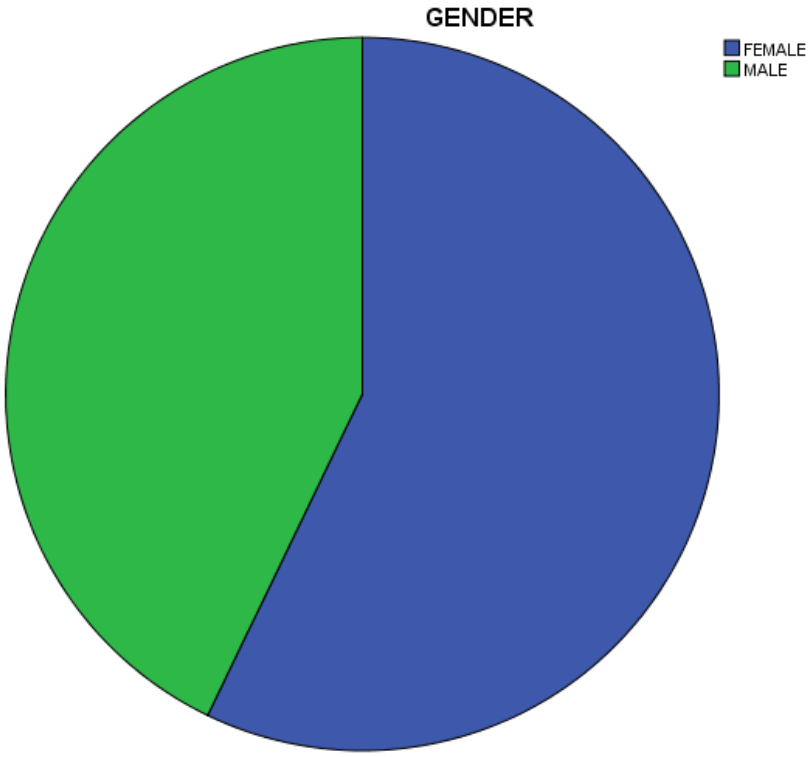

Figure 4.2: Distribution for Gender of the Participants

The distribution for gender of the participants was illustrated at Figure 4.2. According to the pie chart above, it shows that the involvement of the female participants are more than males in this study. The female participants were

reported as 57.1% of the total participants with the frequency 56 out of 98 participants. Besides, the male participants were reported as 42.9% of the total participants with the frequency 42 out of 98 participants.

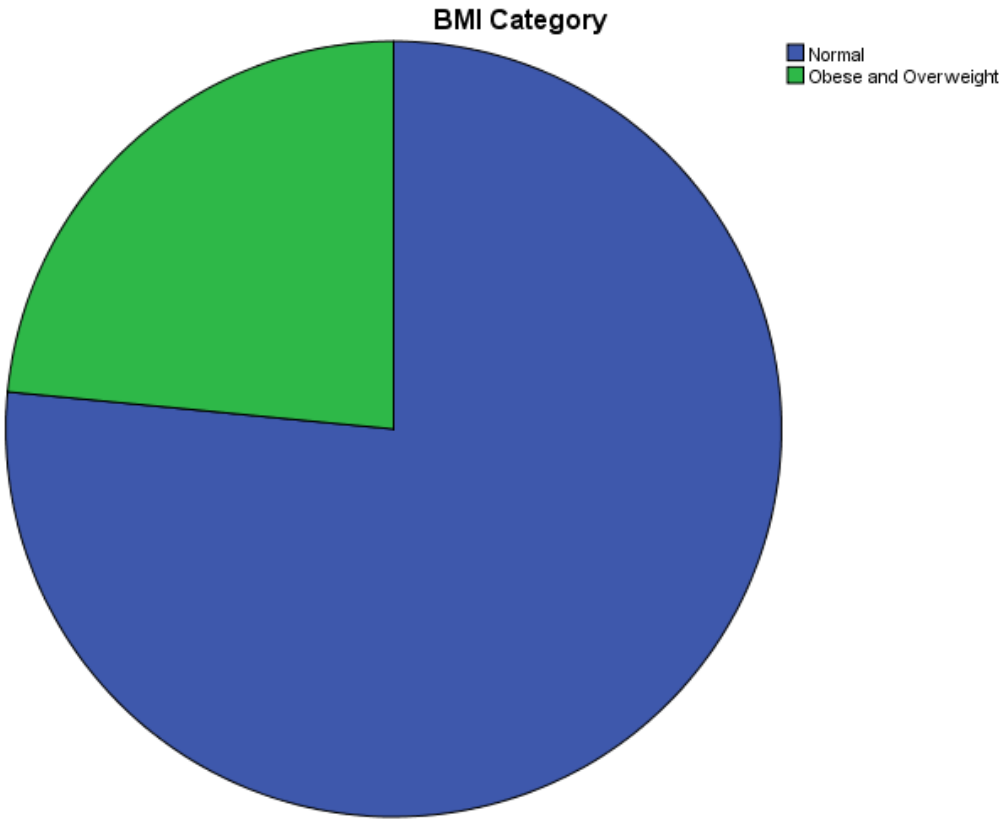

Figure 4.3: Distribution for BMI Category of the Participants

Figure 4.3 shows the BMI category distribution of the participants. Obviously, the pie chart above shows the proportions of the participants with normal BMI value was higher than the participants with obese and overweight. There was 76.5% with the frequency 75 out of 98 participants was identified with

normal BMI. Besides, there was 23.5% with the frequency of 23 out of 98 participants was identified as obese and overweight.

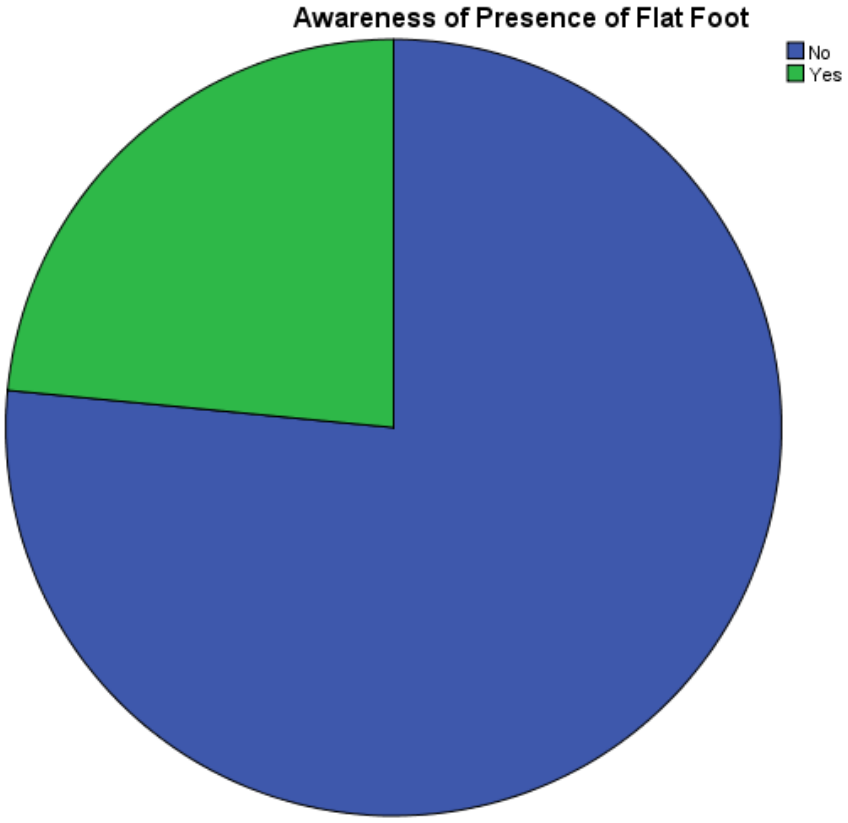

Figure 4.4 Awareness of Presence of Flat Foot Among the Participants

Figure 4.4 illustrates the awareness of the presence of flat foot deformity among the participants in the current study. Based on the pie chart above, the majority of the participants were unaware with the presence of the flat foot. There was 76.5% of the participants with the frequency 75 out of 98 were unaware with the presence of the flat foot while there was only 23.5% of the participants with the frequency 23 out of 98 were aware with the presence of flat foot.

Table 4.2 Degree of Severity on Right and Left Foot Among the Obese and Overweight Participants

Degree of Severity	Side of Flat Foot	
	Right	Left
N	23 (100.0%)	23 (100.0%)
None	2 (8.7%)	2 (8.7%)
1st Degree	5 (21.7%)	3 (13.0%)
2nd Degree	4 (17.4%)	2 (8.7%)
3rd Degree	12 (52.2%)	16 (69.6%)

Note: N = total number of participants.

Table 4.2 illustrated the distribution of the degree of severity between the right and left foot among the obese and overweight participants. There was 23 people in total counted as obese and overweight based on the BMI.

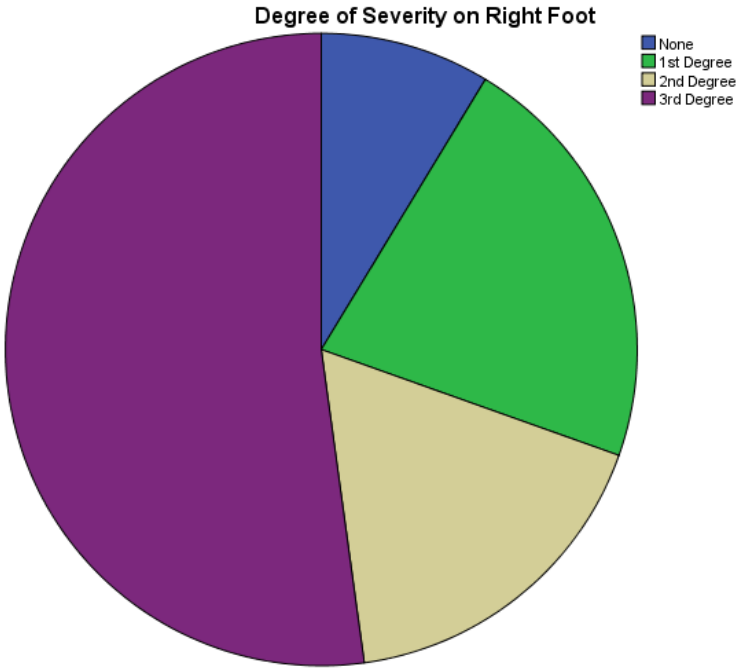

Figure 4.5: Distribution for the Degree of the Severity on Right Foot Among the Obese and Overweight Participants

Figure 4.5 illustrates the distribution for the degree of the severity on the right foot among the obese and overweight participants. According to the pie chart above, there was 23 out of 98 participants were categorized as obese and overweight based on the BMI. Among them, the majority of the obese and overweight participants (52.2%) diagnosed with 3rd degree of flat foot with the frequency 12 out of 23 participants. There were 5 out of 23 (21.7%) and 4 out of 23 (17.4%) of the participants diagnosed with the 1st degree and 2nd degree of flat foot respectively.

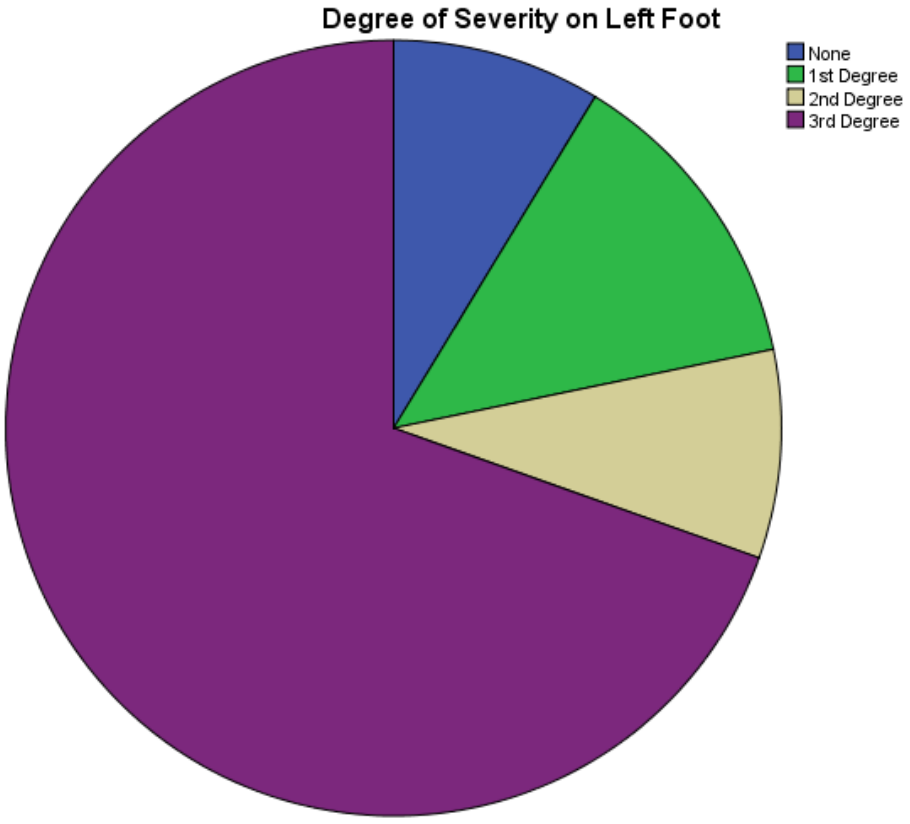

Figure 4.6: Distribution for the Degree of the Severity on Left Foot Among the Obese and Overweight Participants

Figure 4.6 illustrates the distribution for the degree of the severity on the left foot among the obese and overweight participants. According to the pie chart above, there was 23 out of 98 participants were categorized as obese and overweight based on the BMI. Among them, the majority of the obese and overweight participants (69.6 %) diagnosed with 3rd degree of flat foot with the frequency 16 out of 23 participants. There were 3 out of 23 (13.0 %) and 2 out of 23 (8.7 %) of the participants diagnosed with the 1st degree and 2nd degree of flat foot respectively.

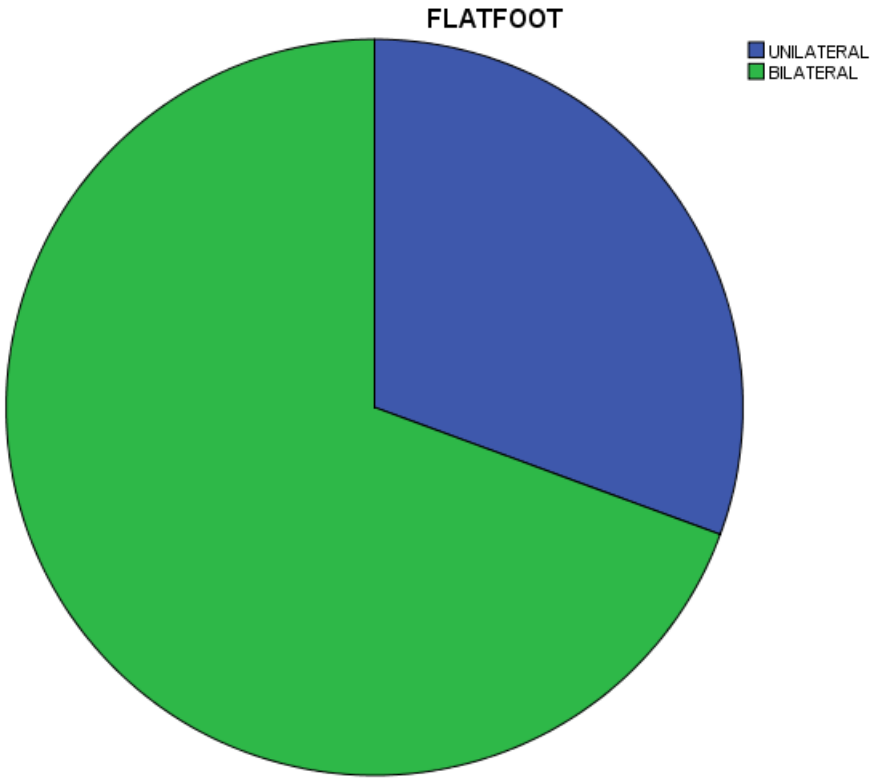

Figure 4.7: Distribution for The Unilateral and Bilateral Flat Foot of The Participants

Figure 4.7 shows the unilateral and bilateral flat foot distribution of the participants. Obviously, the pie chart above illustrates the proportions of the subjects with bilateral flat foot was higher than the participants with unilateral flat foot. There was 69.4% with the frequency 68 out of 98 participants was identified with bilateral flat foot. Besides, there was only 30.6% with the frequency of 30 out of 98 participants was identified as unilateral flat foot.

4.2 Assessment Findings among The Participants

Table 4.3: Assessment Findings Across Gender Distribution

	Gender	
	Male	Female
N	42 (100.0%)	56 (100%)
Pelvic Tilt		
Normal	32 (76.2%)	37 (66.1%)
APT	10 (23.8%)	19 (33.9%)
SIJ		
Normal	21 (50.0%)	28 (50.0%)
Dysfunction	21 (50.0%)	28 (50.0%)

Note: N = total number of participants; APT = Anterior Pelvic Tilt; SIJ = Sacroiliac joints

Table 4.3 above illustrates the assessment findings across the gender distribution in the present study.

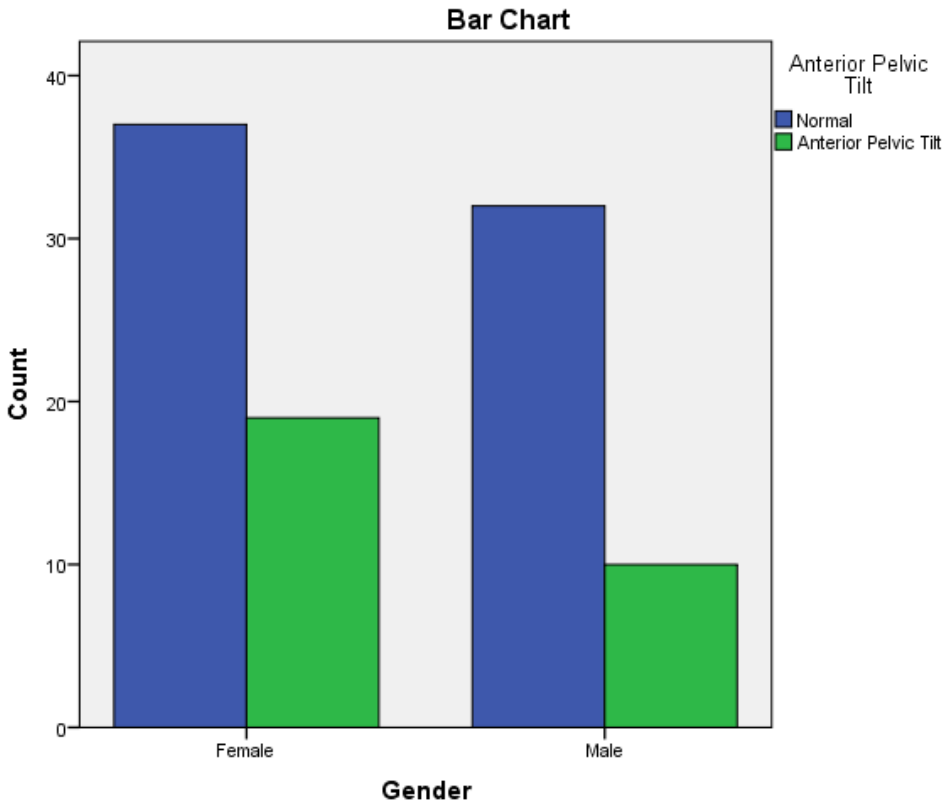

Figure 4.8: Distribution for Anterior Pelvic Tilt Across Gender

Figure 4.8 shows the proportion of presence of the anterior pelvic tilt between boy and girl participants in the present study. The female participants were more prone to develop anterior pelvic tilt than the male participants. Based on the bar chart above, most of the participants were diagnosing with the pelvic tilt within the normal range. There was 66.1% of the female participants with the frequency of 37 out of 56 were having pelvic tilt within the normal range while 33.9% of them were diagnosed with anterior pelvic tilt. Besides, there was 76.2% of male participants with the frequency 32 out of 42 were having pelvic tilt within the normal range while 23.8% of them were diagnosed with anterior pelvic tilt.

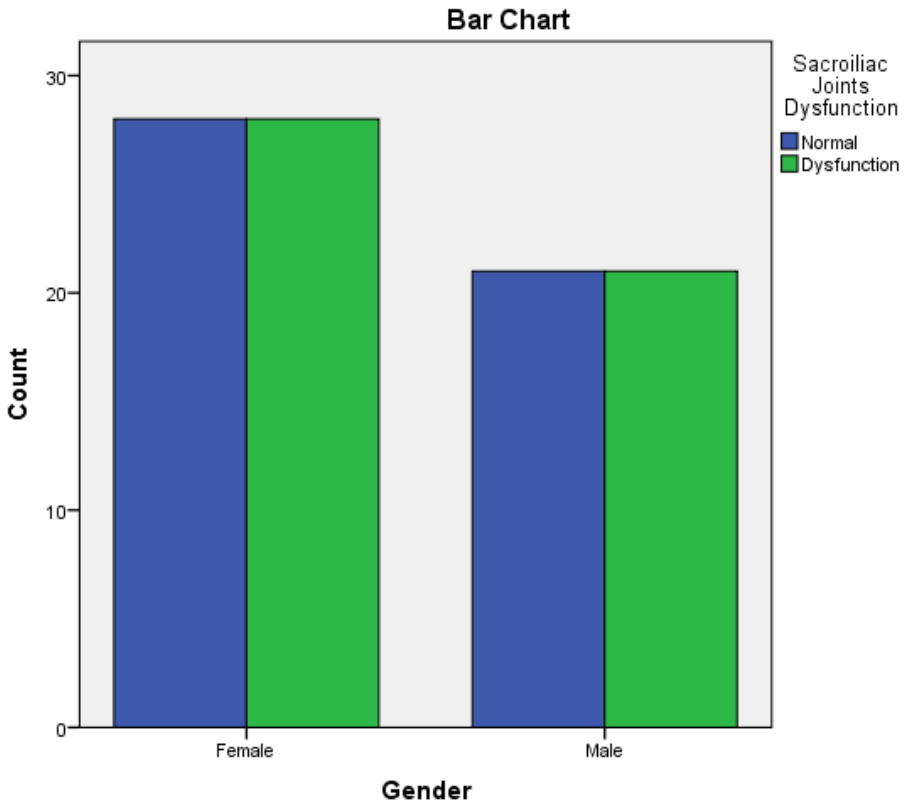

Figure 4.9: Distribution of the Presence of Sacroiliac Joints Dysfunction Across Gender

Figure 4.9 illustrates the distribution of the presence of sacroiliac joints dysfunction between boys and girls in the present study. As the bar chart showed above, there was 50.0% of both female and male participants had sacroiliac joints dysfunction.

Table 4.4: Assessment Findings on the Flat Foot Distribution among The Participants

	Flat Foot	
	Unilateral	Bilateral

N	30 (100.0%)	68 (100.0%)
Gender		
Male	10 (33.3%)	36 (52.9%)
Female	20 (66.7%)	32 (47.1%)
Pelvic Tilt		
Normal	21 (70.0%)	48 (70.6%)
Anterior Pelvic Tilt	9 (30.0%)	20 (29.4%)
SIJ		
Normal	17 (56.7%)	32 (47.1%)
Dysfunction	13 (43.3%)	36 (52.9%)

Note: N = total number of participants; SIJ = Sacroiliac Joints.

Table 4.4 above summarized the assessment findings regarding the position of the pelvic tilt and sacroiliac joints dysfunction based on the flat foot distribution between unilateral and bilateral flat foot among the 98 participants in the present study.

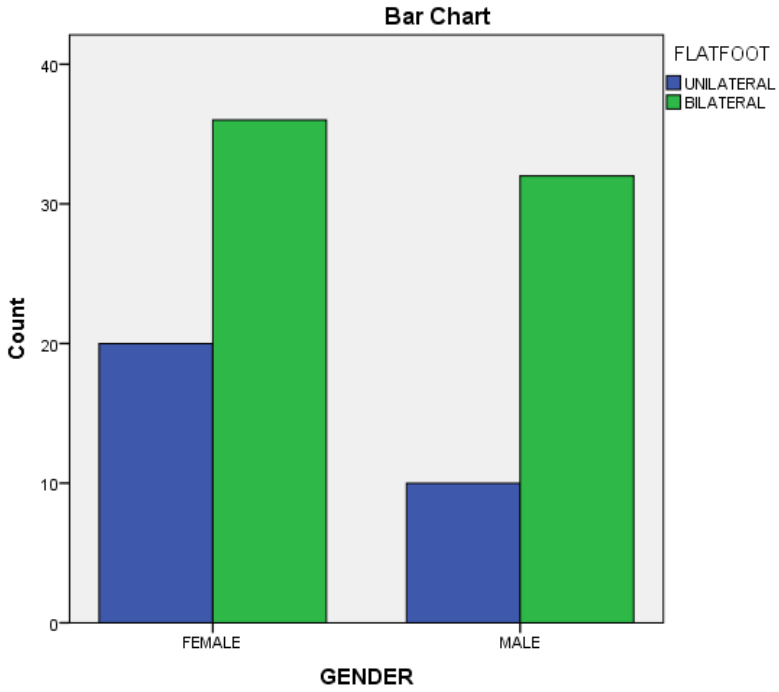

Figure 4.10: Distribution for Flat Foot Across Genders of the Participants

Figure 4.10 shows the distribution proportion of unilateral and bilateral flat foot based on the gender among these 98 participants. As mentioned before, 76.5% of them were identified as bilateral flat foot whereas 23.5% of them were identified as unilateral flat foot. Based on the multiple bar chart above, among the bilateral flat foot participants, it consists of 36 female (52.9%) and 32 male (47.1%) participants. Among the unilateral flat foot participants, it consists of 20 female (66.7%) and 10 of male (33.3%) participants. In short, bilateral flat foot is more prevalent among the undergraduate students.

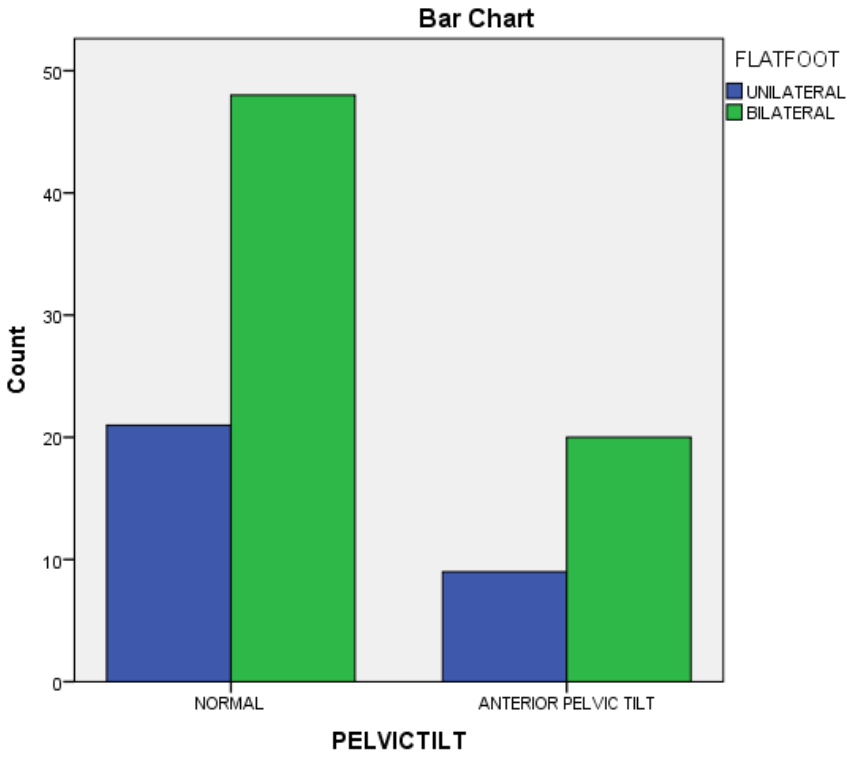

Figure 4.11: Distribution for Anterior Pelvic Tilt of Unilateral and Bilateral Flat Foot Participants

The multiple bar chart in Figure 4.11 illustrates the distribution of excessive anterior pelvic tilt and normal degree of pelvic tilt based on the distribution of the unilateral and bilateral flat foot among the 98 participants. There was only 29.6% with the frequency of 29 out of 98 total participants were identified with excessive anterior pelvic tilt among the total participants. 70.4% of the total participants with the frequency of 69 out of 98 was identified with the normal pelvic tilt degree.

Those participants with unilateral flat foot, 21 of them (70.0%) were having the pelvic tilt within the normal range degree whereas there were only 9 of them (30.0%) were examined as excessive anterior pelvic tilt. For those with bilateral flat foot, there were 20 out of 68 participants (29.41%) were identifed with excessive anterior pelvic tilt whereas 48 out of 68 bilateral flat foot participants (70.59%) were having the pelvic tilt within the normal range degree.

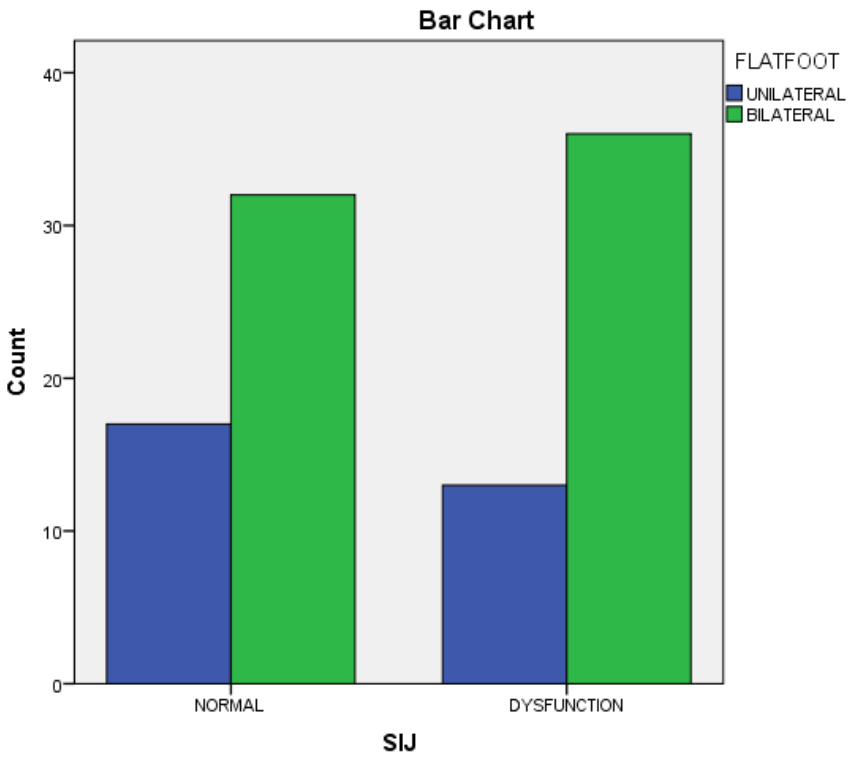

Figure 4.12: Distribution for Sacroiliac Joints Dysfunction of Unilateral and Bilateral Flat Foot Participants

The multiple bar chart in Figure 4.12 illustrates the distribution for the sacroiliac joints dysfunction among both the unilateral and bilateral flat foot participants in the current study. There was distributed equally between the normal function and dysfunction of sacroiliac joint among unilateral and bilateral flat foot. There were 49 of them (50.0%) were reported as their sacroiliac joints were normally functioned whereas another 49 of them (50.0%) were reported as sacroiliac joints dysfunction.

Apart from this, the participants with unilateral flat foot who diagnosed with sacroiliac joints dysfunction were reported as 43.3% with the frrequency of 13 out of 30. 56.7% of them with the frequency of 17 out of 30, their sacroiliac joints were identified with normally function. However, among the bilateral flat foot participants, there were 52.9% with the frequency of 36 out of 68 of the participants were reported as sacroiliac joints dysfunction. 47.1% of them with the frequency 32 out of 69, their sacroiliac joints were examined as normally function.

4.3 Relationship between Anterior Pelvic Tilta and Sacroiliac Joints among Partticipants

Table 4.5: Relationship between Anterior Pelvic Tilt and Sacroiliac Joints among Unilateral and Bilateral Flat Foot Participants.

Pelvic Tilt	SIJ		r	*p* value
	Normal N (%)	Dysfunction N (%)		
Normal	38 (55.1%)	31 (44.9%)	.156	.124
Anterior Pelvic Tilt	11 (37.9%)	18 (62.1%)		

Note: Spearman correlation test was performed. N = number of participants; SIJ = Sacroiliac Joints; r = correlation coefficient value. Level of significant at $p < 0.05$.

Table 4.5 above illustrates the relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among both unilateral and bilateral flat foot

participants. According to the table, there were 98 participants in total. Among them, 69 participants were within normal range of pelvic tilt whereas 29 participants were identified as excessive anterior pelvic tilt. Among the 69 normal pelvic tilt participants, there was 55.1% (n = 38) with normal sacroiliac joints whereas 44.9% (n = 31)of them were diagnosed with sacroiliac joints dysfunction. Among the 29 participants with excessive anterior pelvic tilt, there was 37.9% (n = 11) of them with normal sacroilaic joints whereas 62.1% (n = 18) of them with sacroiliac joints dysfunction.

Therefore, Spearman's correlation test was performed. According to the results that shown at Table 4.5, the correlation coefficient value was 0.156 and the *p* value obtained was 0.124 . Hence, it indicated that there is no significant poor relationship between anterior pelvic tilt and sacroiliac joints dysfunction among both unilateral and bilateral flat foot participants ($p > 0.05$).

4.3.2 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction among Bilateral Flat Foot Participants

Table 4.6 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction among Bilateral Flat Foot Participants.

Pelvic Tilt	Sacroiliac Joints		r	*p* value
	Normal N (%)	Dysfunction N (%)		

Normal	26 (54.2%)	22 (45.8%)	.221	.071
Anterior Pelvic Tilt	6 (30.0%)	14 (70.0%)		

Note: Spearman correlation test was performed. N = number of participants; r = correlation coefficient value. Level of significant at $p < 0.05$.

Table 4.6 above illustrates the relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among the bilateral flat foot participants. According to the Table 4.6, there were 68 participants in total who with bilateral flat foot. Among them, 48 participants were within normal range of pelvic tilt degree whereas 20 participants were identified as excessive anterior pelvic tilt. Among the 48 normal pelvic tilt participants, there was 54.2% (n = 26) with normal sacroiliac joints whereas 45.8% (n = 22) of them were diagnosed with sacroiliac joints dysfunction. Among the 20 participants with excessive anterior pelvic tilt, there was 30.0% (n = 6) of them with normal sacroilaic joints whereas 70.0% (n = 14) of them with sacroiliac joints dysfunction.

Therefore, Spearman's correlation test was performed. According to the results that shown at Table 4.6, the correlation coefficient value was 0.221 and the *p* value obtained was 0.071 . Hence, it indicated that there is no significant poor relationship between anterior pelvic tilt and sacroiliac joints dysfunction among the bilateral flat foot participants ($p > 0.05$).

4.3.3 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction among Unilateral Flat Foot Participants

Table 4.7 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction among Unilateral Flat Foot Participants.

Pelvic Tilt	Sacroiliac Joints		r	*p* value
	Normal N (%)	Dysfunction N (%)		
Normal	12 (57.1%)	9 (42.9%)	.015	.939
Anterior Pelvic Tilt	5 (55.6%)	4 (44.4%)		

Note: Spearman correlation test was performed. N = number of participants; r = correlation coefficient value. Level of significant at $p < 0.05$.

Table 4.7 above illustrates the relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among the bilateral flat foot participants. According to Table 4.7, there were 30 participants in total who with unilateral flat foot. Among them, 21 participants were within normal range of pelvic tilt whereas only five of the participants were identified as excessive anterior pelvic tilt. Among the 21 normal pelvic tilt participants, there was 57.1% (n = 12) with normal sacroiliac joints whereas 42.9% (n = 9) of them were diagnosed with sacroiliac joints dysfunction. Among the nine participants with excessive anterior pelvic tilt, there was 55.6% (n = 5) of them with normal sacroilaic joints whereas 44.4% (n = 4) of them with sacroiliac joints dysfunction.

Therefore, Spearman's correlation test was performed. According to the results that shown at Table 4.7, the correlation coefficient value was 0.015 and the *p* value obtained was 0.939 . Hence, it indicated that there is no significant relationship between anterior pelvic tilt and sacroiliac joints dysfunction among unilateral flat foot participants ($p > 0.05$).

4.4 Gender, BMI, CSI Value, Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Distribution Among Participants Based on The Degree of The Severity of Each Foot

Table 4.8: Gender, BMI, CSI Value, Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Distribution Among Participants Based on Degree of Severity.

	Degree of Severity					
	Right			Left		
	1st Degree	2nd Degree	3rd Degree	1st Degree	2nd Degree	3rd Degree
N	30 (100.0%)	22 (100.0%)	30 (100.0%)	21 (100.0%)	20 (100.0%)	42 (100.0%)
CSI Value (%)	47.00 ± 1.075	54.04 ± 2.506	70.53 ± 8.663	48.09 ± 4.496	54.18 ± 3.975	71.78 ± 6.526
BMI (kgm^{-2})	21.48 ± 3.409	23.02 ± 5.912	23.58 ± 4.018	20.76 ± 3.211	22.01 ± 3.231	23.27 ± 5.777
Gender						
Male	11 (36.7%)	10 (45.5%)	13 (43.3%)	11 (52.4%)	11 (55.0%)	30 (71.4%)
Female	19 (63.3%)	12 (54.5%)	17 (56.6%)	10 (47.6%)	9 (45.0%)	12 (28.6%)

Pelvic Tilt						
Normal	22 (73.3%)	16 (72.7%)	20 (66.7%)	13 (61.9%)	16 (80.0%)	27 (64.3%)
Anterior Pelvic Tilt	8 (26.7%)	6 (27.3%)	10 (33.3%)	8 (38.1%)	4 (20.0%)	15 (35.7%)
Sacroiliac Joints						
Normal	16 (53.3%)	10 (45.5%)	17 (56.7%)	10 (47.6%)	12 (60.0%)	18 (42.9%)
Dysfunction	14 (46.7%)	12 (54.5%)	13 (43.3%)	11 (52.4%)	8 (40.0%)	24 (57.1%)

Note: N = total number of participants; CSI = Chippaux-Smirak Index; BMI = Body Mass Index.

Table 4.7 shows the distribution of the gender, CSI values, BMI values, pelvic tilt alignment, and the nature of sacroiliac joints based on the degree of severity between right and left foot among all participants. The percentages and frequency of these findings were presented at the table above.

4.5 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among Bilateral Flat Foot Participants Based on the Degree of Severity

Table 4.9: Flat Foot Distribution Among Bilateral Flat Foot Participants Based on Degree of Severity

	Degree of Severity					
	Right			Left		
	1st Degree	2nd Degree	3rd Degree	1st Degree	2nd Degree	3rd Degree
N	19 (100.0%)	23 (100.0%)	26 (100.0%)	14 (100.0%)	15 (100.0%)	39 (100.0%)
Pelvic Tilt						
Normal	16 (84.2%)	17 (73.9%)	15 (57.7%)	11 (78.6%)	14 (93.3%)	23 (59.0%)
Anterior Pelvic Tilt	3 (15.8%)	6 (26.1%)	11 (42.3%)	3 (21.4%)	1 (6.7 %)	16 (41.0%)
Sacroiliac Joints						
Normal	12 (63.2%)	12 (52.2%)	8 (30.8%)	10 (71.4%)	4 (26.7%)	18 (46.2%)
Dysfunction	7 (36.8%)	11 (47.8%)	18 (69.2%)	4 (28.6%)	11 (73.3%)	21 (53.8%)

Note: N = total number of participants.

Table 4.9 shows the distribution of the pelvic tilt alignment, and the nature of sacroiliac joints based on the degree of severity between right and left foot among the bilateral flat foot participants. The percentages and frequency of these findings were presented at the table above.

4.5.1 Relationship Between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among 3rd Degree of Bilateral Flat Foot Participants.

Table 4.10: Relationship Between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among 3rd Degree of Bilateral Flat Foot Participants

Pelvic Tilt	Sacroiliac Joints		r	*p* value
	Normal N (%)	Dysfunction N (%)		
Normal	7 (100.0%)	6 (42.9%)	.555	.009
Anterior Pelvic Tilt	0 (0.0%)	8 (57.1%)		

Note: Spearman correlation test was performed. N = number of participants; r = correlation coefficient value. Level of significant at $p < 0.05$.

Table 4.10 above illustrates the relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among the thrid degree of bilateral flat foot participants. According to Table 4.10, there were 21 participants in total who with thrid degree of bilateral flat foot. Among them, 13 participants were having the pelvic tilt within the normal range whereas 8 participant was identified as excessive anterior pelvic tilt. Among the 13 normal pelvic tilt participants, there was 53.8% (n = 7) of them with normal sacroiliac joints whereas 46.2% (n = 6) of them were diagnosed with sacroiliac joints dysfunction. Besides, all of the 8 participants with excessive anterior pelvic tilt also were found with sacroiliac joints dysfucntion.

Therefore, Spearman's correlation test was performed. According to the results that shown at Table 4.10, the correlation coefficient value was 0.555 and the *p* value obtained was 0.009 . Based on the Akoglu (2018), there was a guideline for reporting the strength and direction of correlation coefficients in medical field. Hence, it indicated that there is significant fair and positive relationship between anterior pelvic tilt and sacroiliac joints dysfunction among third degree of bilateral flat foot participants ($r = 0.555$, $p < 0.05$).

4.5.2 Relationship Between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among 1st Degree of Bilateral Flat Foot Participants

Table 4.11: Relationship Between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among 1st Degree of Bilateral Flat Foot Participants

Pelvic Tilt	Sacroiliac Joints		r	*p* value
	Normal N (%)	Dysfunction N (%)		
Normal	6 (75.0%)	2 (100.0%)	-.189	.626
Anterior Pelvic Tilt	1 (25.0%)	0 (0.0%)		

Note: Spearman correlation test was performed. N = number of participants; r = correlation coefficient value. Level of significant at $p < 0.05$.

Table 4.11 above illustrates the relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among the 1st degree of bilateral flat foot participants. According to Table 4.11, there were 9 participants in total who with 1st degree of bilateral flat foot. Among them, 8 participants were having the pelvic

tilt within the normal range whereas only one of the participants were identified as excessive anterior pelvic tilt. Among the 9 participants with normal pelvic tilt, there was 75.0% (n = 6) of them with normal sacroiliac joints whereas 25.0% (n = 1) of them were diagnosed with sacroiliac joints dysfunction. The only one participant with excessive anterior pelvic tilt was associated with normal sacroiliac joints.

Therefore, Spearman's correlation test was performed. According to the results that shown at Table 4.11, the correlation coefficient value was - 0.189 and the *p* value obtained was 0.626 . Hence, it indicated that there is no significant relationship between anterior pelvic tilt and sacroiliac joints dysfunction among 1st degree of bilateral flat foot participants ($p > 0.05$).

4.6 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among Unilateral Flat Foot Participants Based on the Degree of Severity

Table 4.12: Flat Foot Distribution Among Unilateral Flat Foot Participants Based on Severity

	Degree of Severity		
	1st Degree	2nd Degree	3rd Degree
N	20 (100.0%)	5 (100.0%)	3 (100.0%)

Pelvic Tilt			
Normal	15 (75.0%)	3 (60.0%)	2 (66.7%)
Anterior Pelvic Tilt	5 (25.0%)	2 (40.0%)	1 (33.3%)
SIJ			
Normal	14 (70.0%)	2 (40.0%)	1 (33.3%)
Dysfunction	6 (30.0%)	3 (60.0%)	2 (66.7%)

Note: N = total number of participants; SIJ = Sacroiliac Joints.

Table 4.12 above shows the distribution of the pelvic tilt alignment, and the nature of sacroiliac joints based on the degree of severity between right and left foot among the unilateral flat foot participants. The percentages and frequency of these findings were presented at the table above.

4.6.1 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among 1st Degree of Unilateral Flat Foot Participants

Table 4.13: Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among 1st Degree of Unilateral Flat Foot Participants

Pelvic Tilt	SIJ		r	*p* value
	Normal N (%)	Dysfunction N (%)		
Normal	11 (73.3%)	4 (60.0%)	.126	.597
Anterior Pelvic Tilt	3 (26.7%)	2 (40.0%)		

Note: Spearman correlation test was performed. N = number of participants; SIJ = Sacroiliac Joints; r = correlation coefficient value. Level of significant at $p < 0.05$.

Table 4.13 above illustrates the relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among the 1st degree of unilateral flat foot participants. According to Table 4.13, there were 20 participants in total with 1st degree of unilateral flat foot. Among them, there were 14 participants were having the degree of pelvic tilt within the normal range whereas only 6 of the participants were identified as excessive anterior pelvic tilt. Among the 14 participants with normal pelvic tilt, there was 73.3% (n = 11) of them with normal sacroiliac joints whereas 26.7% (n = 3) of them were diagnosed with sacroiliac joints dysfunction. Among the 6 participants with excessive anterior pelvic tilt, there was 60.0% (n = 4) of them with normal sacroiliac joints whereas 40.0% (n = 2) of them were diagnosed with sacroiliac joints dysfunction.

Therefore, Spearman's correlation test was performed. According to the results that shown at Table 4.13, the correlation coefficient value was 0.126 and the *p* value obtained was 0.597 . Hence, it indicated that there is no significant relationship between anterior pelvic tilt and sacroiliac joints dysfunction among 1st degree of unilateral flat foot participants ($p > 0.05$).

4.7 Conclusion

In conclusion, there was 55.7% of prevlant of flat foot deformity among undergraduate students in UTAR. The average age of the participants were 20.33 ± 1.41, whereas the majority from 21 years old students. The participants were average weighted 61.69 ± 14.67 kg and heighted 1.64 ± 0.89 m, with BMI 22.77

$\pm$ 4.44 kg/m^2. There was only 23.5% of them were categorized as obese and overweight. The obese and overweight participants were more prone to develop more severe degree of flat foot deformity. Besides, the awareness of flat foot deformity among the participants was relatively low, there was only 23.5% of them aware with their foot shape. The female participants had more prevalence in developing flat foot than the male participants. However, the male (52.9%) contributes more to bilateral flat foot than the female (47.1%).

The majority of the participants were having bilateral flat foot (69.4%) whereas there was only 30.6% of them identified as unilateral flat foot. The CSI mean score of right and left feet were 55.39 $\pm$ 13.33% and 59.76 $\pm$14.95% respectively. The left foot scored higher than the right foot. Therefore, there was only 29.6% of them diagnosed with anterior pelvic tilt while 50.0% of them diagnosed with sacroiliac joints dysfunction. Based on the findings, the female flat foot participants were more prone to develop anterior pelvic tilt while both genders had the equal chance in developing sacroiliac joints dysfunction. Besides, the bilateral flat foot had greater risk in developing anterior pelvic tilt and sacroiliac joints dysfunction.

There was no significant difference found between anterior pelvic tilt and sacroiliac joints dysfunction among overall unilateral and bilateral flat foot participants. However, there was fair and positive significant difference found

between anterior pelvic tilt and sacroiliac joints among 3rd degree of flat foot participants with r value of 0.555 and *p* value of 0.009.

CHAPTER 5

DISCUSSION

5.0 Introduction

In this chapter, the findings of flat foot with anterior pelvic tilt and sacroiliac joints dysfunction among undergraduate students will be discussed. Apart from this, the limitation and recommendation for the present study will also be discussed in this chapter.

5.1 Demographic Data of the Participants

5.1.1 Prevalence of Flat Foot Among Undergraduate Students in UTAR

There were many studies had been conducted to determine the prevalence of flat foot among different age groups and genders by using various outcome measures in different cities and countries. According to the Gonzalez-Martin et al. (2017), the prevalent of flat foot was 62.0%, assessing by the CSI method. Therefore, the finding from Beheshti et al. (2018) showed the prevalent of flat foot deformity was 74% among the 945 students.

In the present study, there was 176 undergraduate students in UTAR, Sungai Long Campus were involved in this study. Among them, only 98 out of 176 undergraduate students were diagnosed with flat foot deformity by using the CSI method. Therefore, there was prevalent of 55.7% undergraduate students were having flat foot deformity in Universiti Tunku Abdul Rahman, Sungai Long Campus. This result was similar to the Gonzalez-Martin et al. (2017) and Beheshti et al. (2018).

5.1.2 Gender Distribution Among the Participants

The flat foot deformity was not equally distributed between male and female subjects. The males were more prone to develop flat foot deformity. Based on the findings in the current study, the proportion of female (57.1%) students with flat foot was greater than the male (42.9%) students, but the male participants contribute more percentages among the bilateral flat foot. This finding was contradictory with Khadanga & Kumar (2022) and Igbinedion et al. (2022).

It was because the sampling method of this study was a non-probability method which do not ensure every undergraduate student in UTAR were having the equal chance for being selected. The total participants recruited in the current study consist of 58.5% of female students and 41.5% of male students. Hence, the total participants recruited were not equally distributed with the gender and this

might be the cause that affect the findings. However, there was explanation of the higher incidence in developing flat foot deformity among females. The higher prevalence among female was also expected due to the smaller foot bones and less bulky muscles (Pourghasem et al., 2016). In addition, the ankle ligaments laxity was different between male and female. In nature, the female ankle with hyperlaxity and might consider as the potential factors in developing flat foot deformity (Anuruddhika Subhashinie Senadheera et al., 2016).

5.1.3 BMI Category Distribution Among the Participants

Besides, the body weight is highly associated with the occurrence of flat foot deformity. BMI was the tool as the indicator of the body weight. The obese and overweight participants were more prone to develop the more severe degree of flat foot. According to the Suciati et al. (2019), the obese and overweight people had 4.5 times of risk in developing flat foot compared to the healthy subjects. Among the obese and overweight subjects, the midfoot are mostly affected and bear more stress during the weight bearing position. Their longitudinal arch prone to be lower due to the excessive body weight. These structural changes affect the function of medial longitudinal arch and worsen the flat foot deformity. This also explained that the pregnant women had greater chance in developing flat foot deformity. According to Pourghasem et al. (2016), the individuals bearing with excessive weight on the lower extremities would place more load on the foot ligament and soft tissues. The excessive stress and forces loading might induce injuries and deformities in the feet.

Based on the findings in the current study, there was 23.5% of the flat foot participants were categorized as obese and overweight. The category of obese and overweight based on the BMI (CDC, 2021). Based on the findings in the present study, the majority of obese and overweight participants were identified as 3rd degree of flat foot. Besides, the average BMI was higher among the 3rd degree of flat foot deformity. However, this finding matched with the study from Chen et al. (2009), there was a strong significance between flat foot deformity and increased BMI.

5.1.4 Awareness of Presence of Flat Foot Among the Participants

Flat foot deformity was a treatable foot condition, which can be managed with early treatment. As the parental awareness and self-awareness of the flat foot deformity were lack, it might delay the intervention. The congenital flat foot deformity arises since birth so the parental awareness regarding flat foot was also essential. The delay intervention might worsen the deformity and lead to more serious problems. Based on the findings from Son et al. (2017), the report showed that there was significant disagreement between patients' perception pf their foot shape and the assessment results. Besides, the parental awareness toward flat foot deformity was relatively low percentages (82.0%) among the special children's

parents as reported by Phadke et al. (2020). These findings were similar to the current study that reported as 76.5%.

The public may misunderstand regarding the concept of flat foot. The pathophysiology, biomechanics, and clinical presentations of flat foot deformity were complex and not really generalized to public although the flat foot is a widely recognized term. Additionally, the public was not familiar with the symptoms of flat foot. Apart from this, the people only aware the disorder when the clinical presentations arise such as pain and discomfort that interfere their quality of life (QOL). However, the asymptomatic individual might think their feet are normal (Son et al., 2017). According to Phadke et al. (2020), the parents were unaware the predisposing factors of flat foot deformity, including obese and overweight children, genetic factors, and type of footwear.

Therefore, the proper introduction of the exact definition, pathophysiology, biomechanics, predisposing factors, and clinical symptoms of flat foot deformity to the public can increased of awareness regarding flat foot deformity. Besides, the increased of awareness was important for the parents and individuals to prevent and to receive early intervention.

5.1.5 Prevalence of Unilateral and Bilateral Flat Foot Among the Participants

The occurrence of the unilateral and bilateral flat foot was not equal. According to the findings in the current study, the individuals with bilateral flat foot contributed the higher percentages than the unilateral flat foot. There were similar findings were reached before in the study by Ezema et al. (2014), Reddy & Kishve, (2021) and Chen et al. (2009). The bilateral flat foot tends to be greater proportion than the unilateral flat foot. The bilateral flat foot was accounted for 91.5% among the flexible flat foot individuals as reported by Ezema et al. (2014). Therefore, the findings from Reddy & Kishve, (2021), the researcher found that the prevalent of the bilateral flat foot was 11.6% which was greater than the 3% of the unilateral flat foot.

5.1.6 Distribution of the Degree of the Severity of Flat Foot Among the Participants

In the current research, the severity of the flat foot deformity had been categorized into three categories based on the percentages of CSI. According to the findings of the current study, the distribution of 3rd degree flat foot deformity was relatively higher than the 2nd and 1st degree of flat foot. However, this finding was different with the Beheshti et al. (2018). These differences might depend on different factors, such as anatomical, physiological, genetics, type of shoes and insoles, the ages group studied, and the outcome measures used.

5.2 Relationship Between Anterior Pelvic Tilt and Flat Foot Among the Participants

According to Ghasemi et al. (2016), the functionality and structural of lower limbs was altered due to the flat foot. Based on the anatomical linkage in lower limbs, the bilateral flat foot had greater possibility to cause the biomechanical adjustments manifested by the internal rotation of hip and knee joints and led to the forward rotation of the pelvis. Additionally, the increased of internal rotation of hip joints cause the excessive forward and outward position of greater trochanter. This abnormal anatomical position stretched the piriformis muscles chronically. As the piriformis was origin from the anterolateral aspect of the sacrum, then the sacrum mispositioned into an anteroinferior position. Hence, it led to the anterior pelvic tilt in the sagittal plane (Abdel-Raoof et al., 2013). Besides, there was a common finding of the increased of lumbosacral junction angle among the flat foot as reported by Innes (1993). In addition, there was an interaction between the foot and pelvis occurs in a kinematic chain reaction manner. The alternation of the alignment of lower limbs up to pelvic girdle is because of the abnormal forces acting on the foot (Khamis & Yizhar, 2007).

According to Eldesoky & Abutaleb (2015), both bilateral and unilateral flat foot were more prone to develop anterior pelvic tilt than healthy subjects. In addition, the bilateral flat foot individuals had greater degree of the pelvic tilt than the unilateral flat foot individuals. Moreover, the research from Ghasemi et al. (2016) and Eldesoky & Abutaleb (2015) showed that the bilateral flat foot

individuals had the greater chance to develop anterior pelvic tilt than unilateral flat foot individuals. Based on the findings in the current study, there was a prevalent of 29.6% flat foot participants diagnosed with anterior pelvic tilt. The bilateral flat foot participants more prone to develop anterior pelvic tilt. Among the participants with, anterior pelvic tilt, there were 9 of them from unilateral flat foot whereas 20 of them from bilateral flat foot. This finding was matched with the Eldesoky & Abutaleb (2015), Raoof et al. (2013) and Ghasemi et al. (2016). Apart from this, the increased incidence of developing anterior pelvic tilt with the increased of the degree of the severity of the flat foot. According to findings in the current study, the incidence of anterior pelvic tilt was higher, especially among the participants with 3rd degree of flat foot deformity. There were 33.7% and 35.7% of the prevalence in developing anterior pelvic tilt among the third degree of the flat foot between right and left foot. The percentages were relatively higher in third degree of flat foot compared to the first and second degree of flat foot. In short, participants with the bilateral and severe flat foot deformity had more risk in developing anterior pelvic tilt.

5.3 Relationship Between Sacroiliac Joints Dysfunction and Flat Foot Among the Participants

Overpronation of the subtalar joint known as one of the cause factors of developing flat foot. As the flat foot alter the foot mechanic in order to cause internal rotation of femur and tibia, and lead to the anterior pelvic tilt. According

to N. AlKhouli et al. (2017), the poor foot alignment causes the excessive rotation of the hips and led to pathological toe out gait and sacroiliac joints dysfunction. Most of the lower limbs musculoskeletal dysfunction condition can cause the sacroiliac tension and led to dysfunction. Based on the findings in the current study, the prevalence of sacroiliac joints dysfunction was 50.0% among the flat foot participants. Hence, this result was similar to the Fatemeh & Asghar (2008). Both male and female with flat foot deformity had 50% of risk in developing sacroiliac joints deformity.

Besides, the proportion of developing sacroiliac joints between unilateral and bilateral flat foot was slightly different. Based on the findings in the current study, it showed that the bilateral flat foot was more prone to develop sacroiliac joints dysfunction when compared to the unilateral flat foot. When the bilateral flat foot individual ambulates with both pronated feet and ankles, leading to the excessive medial rotation of the legs. The abnormal stress causes the increased of the rotational forces. The excessive rotational force transmitted up from the leg to pelvis, especially on the sacroiliac joints. As most of the forces will stress over the sacroiliac joints and lead to sacroiliac joints dysfunction (Bill Pohlen, 2017). In short, both male and female with flat foot deformity had the equal chance to develop sacroiliac joints dysfunction whereas the people with bilateral flat foot had greater risk in developing sacroiliac joints dysfunction.

5.4 Relationship between Anterior Pelvic Tilt and Sacroiliac Joints Dysfunction Among the Participants

According to Tomankova et al. (2015), the severity of flat foot deformity categorized in three degrees based on the percentages of the CSI value. The first degree of flat foot was between 45.1% to 50.0%; the second degree of flat foot was between 50.1% to 60.0%; the third degree of flat foot was between 60.1% to 100.0%. The functionality and structural alternation of lower limbs increased with the increased of severity of the flat foot deformity. According to the Morino et al. (2018), the study showed that the amount of change in pelvic tilt was related to the sacroiliac joints pain intensity. The pelvic asymmetry alignment had altered the body mechanics and placed strain and stress on various body segments then consequently lead to musculoskeletal pain and dysfunction. Therefore, the patients with sacroiliacs joint pain had greater chance in developing anterior pelvic tilt (Morino et al., 2018).

Excessive anterior pelvic tilt reduces the normal acetabular anteversion in order to potentially affect the patients with acetabular retroversion. The acetabular retroversion which is known as a type of developmental hip dysplasia causing the excessive anterior coverage of femoral head and consequently lead to the primary femoracetabular impingement. Besides, the bilateral flat foot participants had greater degree of anterior pelvic tilt compared with the unilateral flat foot and

healthy participants as reported by Eldesoky & Abutaleb (2015). As the worsening of the flat foot deformity, increasing the alternation from lower limbs up to pelvis for compensating the abnormal foot mechanic. The presence of the subtalar pronation, contributing with the calcaneal eversion and caused the internal rotation of femur and tibia. The increased of internal rotation of hip result in anterior pelvic tilt. The increased of abnormal pelvic rotation also increased the tension on the sacrotuberous ligament as well as increased the friction and stability of the sacroiliac joints. The occurrence of sacroiliac joint dysfunction depends on the line of gravity shifts anteriorly toward the acetabula. This causes the anterior rotation of the pelvic position. Therefore, the dysfunction of sacroiliac joints was pathological associated with the anterior pelvic tilt (DonTigny, 2005).

In the present study, there was no significant relationship were found between anterior pelvic tilt and sacroiliac joints dysfunction among overall either unilateral or bilateral flat foot of all participants. However, the significant relationship had only found between anterior pelvic tilt and sacroiliac joints dysfunction among 3rd degree of bilateral flat foot participants with *p* value of 0.009 as mentioned at Chapter 4. It showed the significant fair and positive relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among 3rd degree of bilateral flat foot participants with the r value of 0.555 as mentioned at Chapter 4. This finding was matched with the result from Falk Brekke et al. However, there is no significant relationship was found between anterior pelvic tilt and sacroiliac joints dysfunction among 1st and 2nd degree of

severity either unilateral or bilateral flat foot participants in the current study. In addition, the 2nd and 3rd degree of the unilateral flat foot was not able to be analyzed due to the very limited participants. Therefore, as the worsening of the flat foot deformity, the greater risk in developing of excessive anterior pelvic tilt and sacroiliac joints dysfunction.

5.5 Limitation of Study

It is acknowledged that there were few limitations are present in the current study. First of all, the present study utilized the convenience sampling method to recruit participants. This sampling method was considered as a non-probability sampling method. In this situation, this does not allow all of the UTAR undergraduate students to have equal chance of being involved and selected in the current study. Moreover, the current study was only conducted in UTAR, Sungai Long Campus. Thus, the findings of this study might not be generalized to all undergraduate students from other universities or colleges. Besides, there are only 98 undergraduate students are recruited in this study due to the limited time restriction. Basically, the total of 98 participants are not enough to produce an efficient outcome and it could not be generalized to all undergraduate students.

Apart from this, the foot ink that be used in the footprints collection is a poster colour due to the cost restriction and it is usually with deep colour for getting a clearer picture of footprints. It will get dirty the feet as well as the clothes of the participants, especially those who wear with longer pants and light colour socks. It is difficult to remove the ink on their feet even after washing with the clean water. This may lead to some dissatisfaction experience of the participants. Besides, the foot ink is reprepared every morning of the screening days. The concentration of the foot ink is uncertain in every times. In some cases, the prepared foot ink is over dilute, and the footprints printed are diffused and exceed out from the foot border. The diffused footprints may confuse the assessor and lead to invalid calculation of CSI value.

5.6 Suggestions and Recommendations

As mentioned previously, the convenience sampling method, which is a non-probability sampling method, was used in the current study to recruit participants. So, it does not have an equal distribution of participants among the undergraduate students, and this might affect the findings. Hence, future research should try to ensure the equal distribution of the participants. The future research may conduct in different universities and colleges, and this also can recruit more participants in the research. In this way, the research with larger sample sizes, the findings will be more persuasive.

Next, there is a recommendation for the future research regarding the collection of footprints. The researchers can use the ink stamp pad to collect the footprints from the participants. This method can avoid the diffusion of the footprints and the ink is easier to wash compared to the poster colour. Apart from this, the author can also use the static and dynamic insole type plantar pressure device to assess the flat foot deformity. This device can assess the pressure when the plantar surface of the foot contact to the ground and during locomotion (Hsu et al., 2018).

Lastly, it is recommended that the duration for preparation of research and the data collection can be increased to a longer period. This is because there is a lot of restriction in term of selection of research design, method, and participants recruitment. Moreover, the data collection is only lasted for 2 weeks in the present study, it is difficult to recruit a larger population of participants to produce a quality data. When the longer duration is provided to the students, it is believed that the quality of the research project implemented can be increased.

CHAPTER 6

CONCLUSION

In conclusion, the flat foot deformity was a common observed foot condition among the undergraduate students as the current study was reported 55.7% of prevalence. In addition, the severity and occurrence of the flat foot deformity were highly associated with the BMI. The subjects with the higher the BMI, the greater chance to develop the flat foot deformity with the more severe degree. The CSI was relatively higher among the obese and overweight flat foot individuals. Besides, the occurrence of bilateral and unilateral was not equally distributed in the present study. Generally, the occurrence of bilateral flat foot was greater the unilateral flat foot.

Therefore, there is a positive and fair relationship between the anterior pelvic tilt and sacroiliac joints dysfunction among the 3rd degree of bilateral flat foot undergraduate students. The relationship between anterior pelvic tilt and sacroiliac joints was highly depends on the degree of the severity of the flat foot deformity. The more severe degree of the flat foot deformity led to more serious of the lower limbs and pelvis mechanic alternation. As mentioned at the Chapter 5, the flat foot deformity had altered the lower limbs mechanic up to the pelvis. The

overpronation of foot induced the internal rotation of hips and knees into abnormal position. Then, the pelvic tends to tilt anteriorly into the excessive forward position. The anterior pelvic tilt placed more stress and load over the sacroiliac joints and led to pain and dysfunction chronically. In this way, the individuals with severe flat foot deformity with the poor posture might experience low back pain with the hypo- or hypermobility of sacroiliac joints. Moreover, the pain and the mobility restriction may interfere activities of daily living (ADL) and quality of life (QOL) of the patients.

Moreover, most of the flat foot participants had compliant they were having unspecific low back pain during the QnA session, and the majority of participants were unaware with their foot shape. Thus, the parental awareness and self-awareness toward the flat foot deformity should be increased as most of them were unaware with their foot shape and foot mechanic. This might lead to delay intervention while the asymptomatic flat foot subjects might misunderstand that they are normal feet. Additionally, the subjects who delayed interventions or left treated might worsen the deformity and subsequently cause alternation of lower limbs. According to the results of this research, the worsening of flat foot deformity might increase the risk of developing anterior pelvic tilt and sacroiliac joints dysfunction.

In the future research, it is recommended that the researcher may involve the prevalence of low back pain and perform the study with the larger size of participants. Since the relationship between anterior pelvic tilt and sacroiliac joints dysfunction showed significant relationship among 3rd degree of the flat foot participants, and the low back pain consider as a common symptom of sacroiliac joints dysfunction. The future study can investigate that the sacroiliac joints dysfunction can be one of the causes that due to the arising of low back pain among the flat foot individuals. Besides, the future study may include more undergraduate students from other universities and colleges to generalize the results and enhance the applicability of the research findings.

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APPENDICES

APPENDIX 1

ETHICAL APPROVAL LETTER

UNIVERSITI TUNKU ABDUL RAHMAN
Wholly Owned by UTAR Education Foundation (Company No. 578227-M)

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	4 November 2022 – 3 November 2023
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		
4.	Knowledge and Awareness Towards Pneumonia Among UTAR Non-Health Sciences Undergraduate Students	Chooi Yan Yee	Pn Nurul Husna Binti Khairuddin	
5.	The Effect of Active Video Games on 6-Minute Walk Test in Overweight and Obese Children	Chin Jay Ven		
6.	Association of Functional Ability of Upper Extremity and Scoliosis Among College Students: A Correlational Study	Sammi Leong Sing Yee	Dr Deepak Thazhakkattu Vasu	
7.	A Correlation Study Between Achilles Tendon Contracture and Posterior Tibial Tendon Dysfunction on Ankle Instability Among Young Adults with Pes Planus	See Wan Ni		
8.	A Correlational Study of the Relationship Between Flat Foot with Anterior Pelvic Tilt and Sacroiliac Joint Dysfunction Among Undergraduate Students	Tan Bee Thong		
9.	Association Between Physical Activity, Learning Style and Academic Performance Among UTAR Health Science Undergraduates	Yeoh Zhe Yi	Ms Kamala a/p Krishnan	

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Website: www.utar.edu.my

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
31.	Association of Postural Awareness with Sedentary Behavior and Back Pain During the Hybrid Study Among Undergraduate Students	Low Xin Yuen	Mr Martin Ebenezer Chellappan	4 November 2022 – 3 November 2023
32.	Impact of Social Media Addiction on Physical Activity Among Undergraduate Students	Mak Kai Nan		
33.	Tibial Torsion and Leg Length Discrepancy in Idiopathic Scoliosis Among UTAR Students	Khoo Wan Qi	Pn Nadia Safirah Binti Rusli	
34.	Prevalence of Patellofemoral Pain Among University Students	Khoo Wen Han		
35.	Prevalence of Varicose Veins Among Fast Food Employees in Cheras, Selangor: A Cross Sectional Study	Ropheca Phuah Su Hui		
36.	The Effect of Unstable Modified Wall Squat on Dynamic Balance Among Recreational Athletes	Chu Sin Jiet	Mr Sathish Kumar Sadagobane	
37.	Knowledge, Perception, and Attitude Towards Breast Cancer and Breast Self-Examination (BSE) Among Non-medical Private University Students	Foo Jes Mynn		
38.	Perception, Knowledge and Attitude Towards the Impact of Daytime Nap on the Risk of Stroke Among Non-Healthcare Undergraduate Students: A Cross-Sectional Study	Chan Chi Kuan	Mr Tarun Amalnerkar Co-Supervisor: Ms Swapneela Jacob	
39.	Awareness, Knowledge and Attitude Toward Orthostatic Hypotension Among Elderlies	Ch'ng Hui Kee		
40.	Effect of TikTok on Student Learning Among Physiotherapy Students	Tan Eng Jing	Mr Avanianban Chakkarapani	
41.	Awareness Towards Tourette Syndrome Among Health Science and Non-health Science Students in A Private University, Malaysia	Tan Kai Xuan		
42.	Effect of Scapular Retraction Exercise on Forward Head Posture Among University Students	Tay Kai Wei	Ms Mahadevi A/P Muthurethina Barathi	
43.	Comparison Between Effect of Lower Limb Cyclic Stretching and Ballistic Stretching on Jumping Distance Among Undergraduate Students: A Comparative Study	Ng Zi Ru		
44.	Relationship of Physical Activity with Anxiety and Depression Among University Students	Ong Aiwei		
45.	Gender Discrepancy and Its Association with Shoulder Pain Among Malaysian Recreational Badminton Players	Khoo Je-Yique	Pn Nur Aqliliriana Binti Zainuddin	
46.	Obesity, Eating Habits and Physical Activity Before and During Covid-19 Pandemic Among University Lecturers	Khoo Tze Sean		

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.

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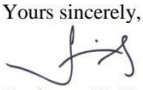
Tel: (603) 9086 0288 **Fax**: (603) 9019 8868
Website: www.utar.edu.my

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

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APPENDIX 2

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
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.

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.

8. You may access and update your personal data by writing to us at megan2001@1utar.my

Acknowledgment of Notice
[ ] I have been notified and that I hereby understood, consented and agreed per UTAR above notice.
[ ] I disagree, my personal data will not be processed.

……
Name:
Date:

APPENDIX 3

INFORMATION SHEET AND INFORMED CONSENT FORM

Research Participant Information Sheet

Universiti Tunku Abdul Rahman
Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

Information Sheet to Participate in the A Correlational Study of the Relationship Between Flat Foot with Anterior Pelvic Tilt and Sacroiliac Joint Mobility among undergraduate students

Student Investigator: Tan Bee Thong
Department: Physiotherapy
Course Name and Course Code: UMFD3026 Research Project

Year and Semester: Year 3 Semester 2
Supervisor: Mr. Deepak Thazhakkattu Vasu

You are being asked to volunteer for this 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 study is to determine the relationship between flat foot with anterior pelvic tilt deformity and sacroiliac joint mobility among young adults.

Approximately 401 students will participate in this study.

Procedures

If you agree to be in this study, you will be going through a total of 2 stations once you are found to be eligible through screening conducted by our examiner.

Screening for flat foot deformity:

You will be asked to immerse both feet into the ink-colored water then make both the footprints on a piece of blank paper provided.

You are eligible to proceed to next station if the CSI result ≥ 45.1%.

Station 1 – Anterior pelvic tilt screening
In this station, you will be asked to take off your shoes and socks then stand erect on the flat ground. The therapist will palpate the anatomical landmarks: anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS), for the measurements. After palpated the anatomical landmarks, the therapist will place a labelled sticker on the landmarks for accurate measurements. Three trials of measurement will be done in this station to minimize the error.

Station 2 – Shimpi prone SIJ test
In this station, you will be asked to lie on your tummy on a plinth provided. The therapist will place the palm under your anterior superior iliac spine (ASIS). Meanwhile, you are requested to extend your hip with leg straight to off your foot from the plinth.

Upon completing all stations, you will be notified with your result of these tests.

Length of Participation

This study will be conducted for approximately 30 minutes.

Risks and Benefits

There are minimal risks from being in this study. In case of injury, you will receive treatment and care which will be provided at the expense of researcher. The participants who are involved in this study will gain some basic knowledge and managements on flat foot and the relative complications.

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 011-10708308 or megantan308@gmail.com.
The Course Coordinator can be contacted at Mr. Deepak Thazhakkattu Vasu, deepak@utar.edu.my, concerns, or complaints about the research and wish to talk to someone other than individuals on the research team.
Please keep this information sheet for your records.

Research Participant Consent Form

Universiti Tunku Abdul Rahman
Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

Consent Form to Participate in the A Correlational Study of the Relationship Between Flat Foot with Anterior Pelvic Tilt and Sacroiliac Joint Dysfunction Among Undergraduate Students

Student Investigator: Tan Bee Thong
Department: Physiotherapy
Course Name and Course Code: UMFD3026 Research Project

Year and Semester: Year 3 Semester 2
Supervisor: Mr. Deepak Thazhakkattu Vasu

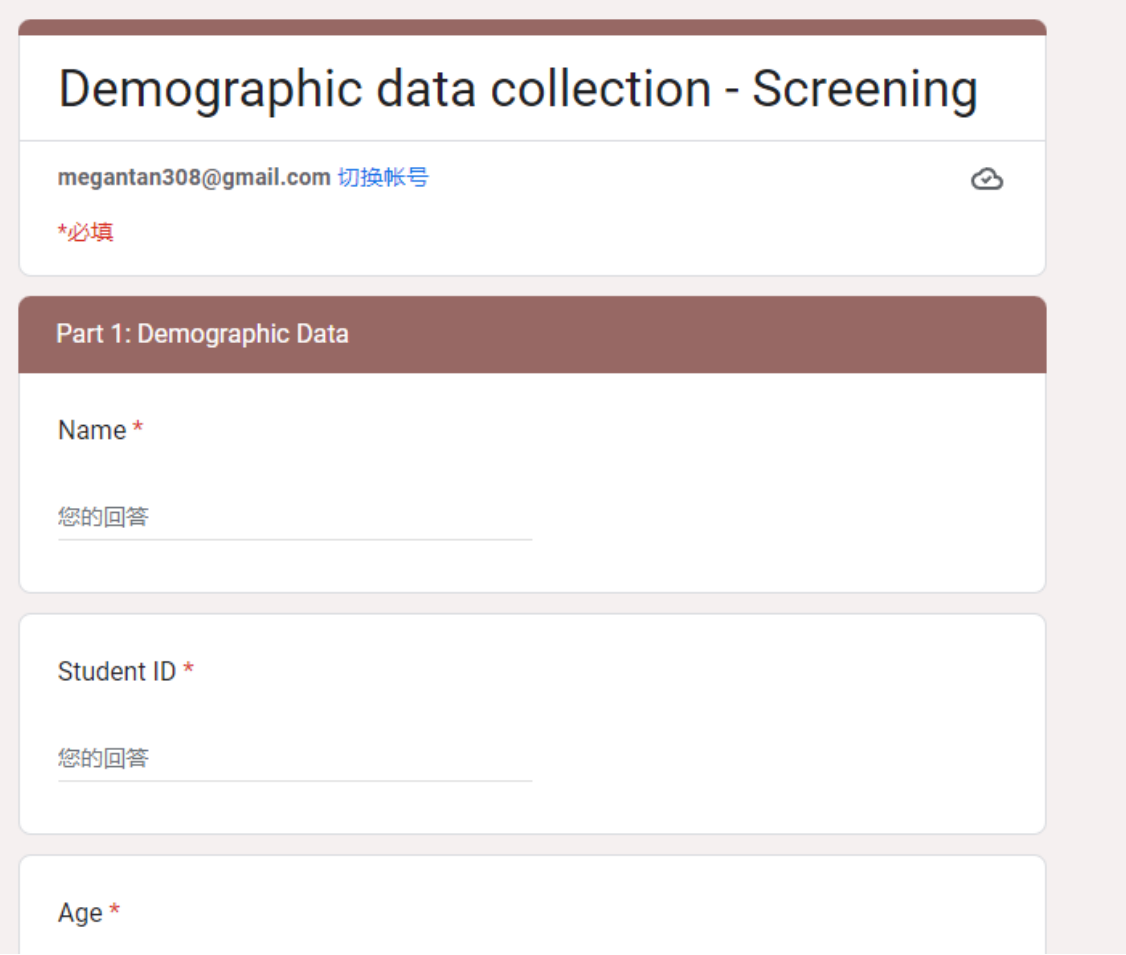
I have read the provided information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have, has been answered to my satisfaction. I understand that I will be given a copy of this form, and the researcher will keep another copy on file. I consent voluntarily to be a participant in this study.

Name of Participant: _____

IC No: _____ Date: _____

APPENDIX 4

Demographic Data Collection Form



Age *

选择

Gender *

- Male
- Female
- Prefer not to say

Are you aware that you have flat foot? *

- Yes
- No

上一页 下一页 清除表单内容


Part 2: Medical History
Q1 Had you underwent corrective surgery for your foot in the past 1 month? *
Yes
No
Q2 Do you have any spinal deformity? E.g.: Scoliosis *
Yes
No
向我发送我的回复的副本。
上一页
提交
清除表单内容

APPENDIX 5

Assessment Data Collection Form

1. Body Mass Index (BMI)

   Formula: BMI = weight (kg) / height (m) ^{2}

Height (m)	Weight (kg)	BMI

2. Chippaux-Smirak index (CSI)
   Formula: CSI (%) = (h/f) x 100%

	h (cm)	f (cm)	CSI (%)
Lt			
Rt			

3. Pelvic tilt angle

Formula: Sin θ= (A-B)/C

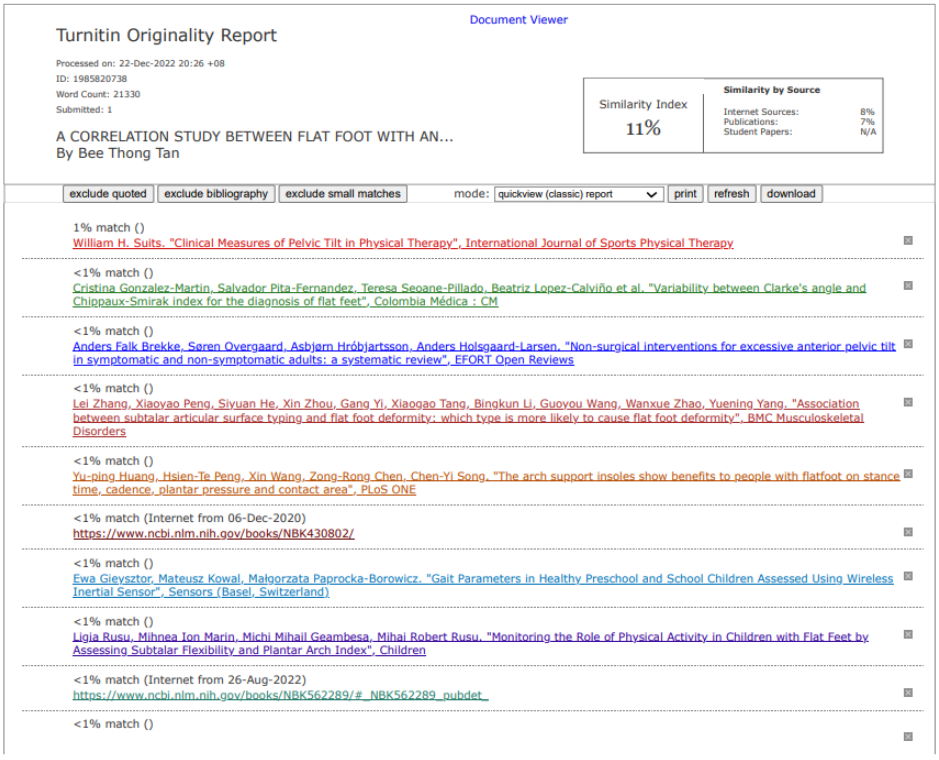
	A	B	C	
Trial 1				
Trial 2				
Trial 3				
Average				

4. Shimpi Prone SIJ test

Left	Right

APPENDIX 6

TURNITIN REPORT



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By Bee Thong Tan

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Anders Falk Brekke, Søren Overgaard, Asbjørn Hróbjartsson, Anders Holsgaard-Larsen, "Non-surgical interventions for excessive anterior pelvic tilt in symptomatic and non-symptomatic adults: a systematic review", EFORT Open Reviews

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Lei Zhang, Xiaoyao Peng, Siyuan He, Xin Zhou, Gang Yi, Xiaogao Tang, Bingkun Li, Guoyou Wang, Wanxue Zhao, Yuening Yang, "Association between subtalar articular surface typing and flat foot deformity: which type is more likely to cause flat foot deformity", BMC Musculoskeletal Disorders

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Ewa Gieysztor, Mateusz Kowal, Małgorzata Paprocka-Borowicz, "Gait Parameters in Healthy Preschool and School Children Assessed Using Wireless Inertial Sensor", Sensors (Basel, Switzerland)

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Ligia Rusu, Mihnea Ion Marin, Michi Mihail Geambesa, Mihai Robert Rusu, "Monitoring the Role of Physical Activity in Children with Flat Feet by Assessing Subtalar Flexibility and Plantar Arch Index", Children

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