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TIBIAL TORSION AND LEG LENGTH DISCREPANCY

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TIBIAL TORSION AND LEG LENGTH DISCREPANCY IN IDIOPATHIC SCOLIOSIS AMONG UTAR STUDENTS

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By

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TIBIAL TORSION AND LEG LENGTH DISCREPANCY IN IDIOPATHIC SCOLIOSIS AMONG UTAR STUDENTS

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ABSTRACT

Background: Scoliosis may affect the bone anatomy and biomechanics of the lower extremity. Tibial torsion and leg length discrepancy are crucial anatomical characteristics in clinical setting. However, the prevalence of tibial torsion and leg length discrepancy in idiopathic scoliosis have not been reported. This study aimed to investigate the prevalence of tibial torsion and leg length discrepancy among idiopathic scoliosis.

Methods: A cross-sectional study was conducted with 29 idiopathic scoliosis. Lower extremities assessment included tibial torsion and leg length discrepancy. Descriptive analysis was used to analyze participant characteristics and prevalence of tibial torsion as well as leg length discrepancy. Paired-samples T test was used to identify the mean difference of common thigh foot angle between both contralateral sides of the lower extremities.

Results: The highest prevalence of torsion of tibia is internal tibial torsion with 58.6%, followed by 37.9% normal tibial torsion and 3.4% external tibial torsion. More males have abnormal tibial torsion than female. The number of participants with abnormal tibial torsion were found to be more in males on the left side and slightly more in females on the right side. The common thigh foot angle revealed in this study is 11.40°. There is no significant mean difference in common thigh foot angle between both contralateral sides of the lower extremities. Thigh foot angle for internal tibial torsion is likely prevalent on the left tibia. Only 1 out of 29 participants (3.4%) have true LLD. LLD is not likely prevalent in idiopathic scoliosis.

Conclusion: The tibial torsion among idiopathic scoliosis was reported in this study especially the internal tibial torsion. Thigh foot angle is more likely prevalent on the left lower extremity and more on male group. Lower extremity screening should assist in the identification of tibial torsion and leg length discrepancy. This

may then lead to early prevention of lower limb pathology. Future studies may conduct with larger sample size in relation to current study. Possible risks of high thigh foot angle in adolescent idiopathic scoliosis may conduct in future study.

Key Words: Tibial torsion, Leg Length Discrepancy, Idiopathic Scoliosis

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APPROVAL SHEET

This Research project entitled "**TIBIAL TORSION AND LEG LENGTH DISCREPANCY IN IDIOPATHIC SCOLIOSIS AMONG UTAR STUDENTS"** was prepared by KHOO WAN QI and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (Honours) at Universiti Tunku Abdul Rahman.

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PERMISSION SHEET

It is hereby certified that **KHOO WAN QI** (ID No: **20UMB06268**) has completed this Research project entitled "TIBIAL TORSION AND LEG LENGTH DISCREPANCY IN IDIOPATHIC SCOLIOSIS AMONG UTAR STUDENTS" under the supervision of PUAN NADIA SAFIRAH BINTI RUSLI (Supervisor) from the Department of Physiotherapy, Faculty of Medicine and Health Sciences. I hereby give the permission to the University to upload the softcopy of my final year project in pdf format into UTAR Institutional Repository, which may be made accessible to the UTAR community and public.

Yours truly,

_____

(KHOO WAN QI)

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.

Name: KHOO WAN QI

Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviations

BMI	Body Mass Index
LLD	Leg Length Discrepancy
TFA	Thigh Foot Angle
TT	Tibial Torsion
UTAR	Universiti Tunku Abdul Rahman

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Scoliosis is a complex three-dimensional deviation of the spinal axis whereby a lateral curvature of greater than 10° is observed through a posteroanterior radiography. Because of the spinal self-rotating action, scoliosis forms a complex curvature that causes abnormalities in not only the coronal plane but in all three planes (Trobisch, Suess & Schwab, 2010). Approximately 80% of structural coronal deformities are caused by idiopathic scoliosis. Idiopathic scoliosis is a diagnostic of exclusion, diagnosed only when the history, clinical and radiological data do not clearly point to any particular etiology (Trobisch et al., 2010). Generally, idiopathic scoliosis is classified into 3 sub-groups based on the age at which it is first noted as infantile (0-2 years), juvenile (3-9 years) and adolescent (10 years until skeletal maturity) (Choudhry, Ahmad & Verma, 2016). Adult scoliosis is the fourth category which can be either the continuation of adolescent idiopathic scoliosis or a de novo development caused by degenerative changes or other factors (Trobisch et al., 2010).

Several studies have focused on the etiology of idiopathic scoliosis, the classification of curvatures, x-ray morphology and how the disorder affects the biomechanical balance of the body. The abnormalities found in the sagittal and

coronal balance of the spine are likely the greatest indicators of idiopathic scoliosis, but this disorder is a complex 3D deformity that affects the entire body and these effects must not be ignored (Márkus, Schlégl, Burkus, József, Niklai, Than & Tunyogi-Csapó, 2018). For instance, significant asymmetries in the hip rotational motion, despite remained constant in range of motion and abnormalities in posture as well as walking pattern noticed in scoliosis patients are reported by Kotwiczki et al., (2008) and Yagi et al., (1994) in respective studies. These studies suggested that changes caused by idiopathic scoliosis may affect the bone anatomy and biomechanics of the lower extremity (Márkus et al., 2018).

According to the study conducted by Márkus et al. in 2018, out of 15 examined biomechanical parameters of the lower limb, tibial torsion is one of the parameters with a significant difference between both sides. Total lower limb length is the other parameter which is found to have a significant difference between both sides (Márkus et al. in 2018). In 2014, Gandhi and his colleagues reported the prevalence of tibial torsion among normal, overweight and obese individuals in India. From their findings, they found significant difference in tibial torsion between contralateral sides (Gandhi, Singla, Kullar, Agnihotri, Mehta, Suri, R & Rath, 2014). Numerous studies found that tibial torsion is the most common cause of coupled pelvic rotation, hip abduction and hip adduction, contralateral lower limb compensation, further leading to in-toeing gait and knee pathology (Hudson, 2016; Radler, Kranzl, Manner, Höglinger, Ganger & Grill, 2010; Paulos, Swanson, Stoddard & Barber-Westin, 2009).

The American Academy of Orthopaedic Surgeons, the Scoliosis Research Society, the Pediatric Orthopaedic Society of North America as well as the American Academy of Pediatrics established a task force in 2008 to review the issues surrounding scoliosis screening. A conclusion of that task force issued an information statement is although screening has limitations, the potential benefits that idiopathic scoliosis patients receive from early treatment can be significant (Burton, 2013). Screening for scoliosis is vital in that of earlier detection and diagnosis that permit early conservative treatment, preserve higher scores in health-related quality of life and prevent unnecessary risky surgery (Deepak, Ong, Choon, Lee, Chiu, Chan & Kwan, 2017). Late detection may cause progression to severe scoliosis at which pulmonary function, self-image of the patients will be affected (Deepak et al., 2017) and may further induce the negative biomechanical effects of tibial torsion. A study by Metgud et al., 2022 revealed torsion of the tibia causes notable biomechanical change in the alignment of bone and joint. Determination of tibial torsion in idiopathic scoliosis plays an important role indeed. The aim of this study is to study the prevalence of tibial torsion in idiopathic scoliosis among UTAR students. Secondarily, determine the common thigh foot angle and compare between contralateral sides of the lower limbs among this population. Tertiary, identify the total lower limb length in idiopathic scoliosis.

After searching copious number of articles through different data bases, there are many studies conducted to investigate tibial torsion and thigh foot angle previously (Stuberg, Temme, Kaplan, Clarke & Fuchs, 1991; Yagi, 1994; Burwell, Kirby, Cole, Webb, Moulton & Cavdar, 1997, 2008; Lee, Chung, Park, Choi & Cho, 2009; Márkus et al., 2018). Among these studies, they targeted on different populations which includes normal developing children, pediatric, adults, children with myelomeningocele, patient with medial type osteoarthrotic knees, adolescent idiopathic scoliosis (AIS) and cerebral palsy. Many of the studies have been conducted for more than a decade whereby some of the information was less reliable and less developed. In conclusion, the tibial torsion in idiopathic scoliosis among university students is still limited and not well-studied.

There are a few similar studies which have been conducted in foreign countries. However, the values are not able to be applied nationwide. According to the studies conducted by Weinberg, Park, Morris & Liu in 2017, Hovinga & Lerner in 2009, Tamari, Briffa, Tinley & Aoyagi in 2007, Yagi in 1994 and Moussa in 1994, the typical degrees of tibial torsion appear to be influenced by geographic and cultural differences. Numerous other civilizations around the world may exhibit similar but as of yet unknown variations due to environmental factors (Snow, 2021).

Most of the idiopathic scoliosis individuals are lacking in body awareness (Yagci, Karatel & Yakut, 2020). They may be less likely to identify where their bodies are in shapes. For instance, tibial torsion that happened in the lower extremities which may cause changes to their body in different ways. Although a lot of studies on scoliosis screening has been carried out among school children, there will be someone who missed the chances. Therefore, they may be unaware of the presence of scoliosis which may cause further influences. Hence, scoliosis screening among university students is extraordinary important. Based on all the above statements, more studies still need to be conducted so that more in-depth references can be reviewed from multiple perspectives and further contribute to previous as well as future research which in relation to idiopathic scoliosis.

1.2 Research Question

1. What is the prevalence of tibial torsion in idiopathic scoliosis among UTAR students?
2. Is there any difference in common thigh foot angle between both lower extremities in idiopathic scoliosis among UTAR students?
3. What is the prevalence of LLD among UTAR students with idiopathic scoliosis?

1.3 Objectives

1. To determine the prevalence of tibial torsion in idiopathic scoliosis among UTAR students
2. To compare the common thigh foot angle between both lower extremities in idiopathic scoliosis among UTAR students
3. To determine leg length discrepancy in idiopathic scoliosis among UTAR students

1.4 Hypothesis

Objective 1:

No hypothesis.

Objective 2:

H_0: There is no significant difference in thigh foot angle between both lower extremities in idiopathic scoliosis among UTAR students.

H_A: There is significant difference in thigh foot angle between both lower extremities in idiopathic scoliosis among UTAR students.

Objective 3:

No hypothesis.

1.5 Operational Definition

1. Tibial torsion: Tibial torsion refers to any twisting of the tibia along its longitudinal axis that results in an alteration of the alignment of the planes of motion of the proximal and distal articulations (Hutter & Scott, 1949).
2. Leg length discrepancy: Leg length discrepancy refers to a condition in which noticeably unequal length in the paired lower extremity limbs (Gurney, 2002).
3. Scoliosis: Scoliosis is a complex three-dimensional deviation of the spinal axis whereby a lateral curvature of greater than 10° in the coronal plane is detected (Trobisch, Suess & Schwab, 2010).
4. Idiopathic scoliosis: Idiopathic scoliosis is a type of scoliosis which is diagnosed only when there is a lack of unambiguous evidence for a particular etiology in the history, clinical, and radiological data (Trobisch et al., 2010).
5. UTAR students: UTAR students who are studying in Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus and Kampar Campus.

1.6 Rationale of Study

The prevalence of adolescent idiopathic scoliosis varies between 1% and 3% according to Menger & Sin (2022). Scoliosis can range in severity from mild to severe due to its various traits or types. Since idiopathic scoliosis has a propensity to be painless and the physical examination does not necessarily involve a check of

the skeletal systems, it is frequently overlooked by the primary healthcare professionals (Hengwei et al., 2016). Majority of the people could not be aware that they are having scoliosis. Another common misunderstanding is that some individuals believe that a person without any symptoms does not always have scoliosis. Scoliosis cannot be stopped from developing (Trobisch et al., 2010). Early detection is therefore the current priority to deliver treatment promptly. Therefore, only early diagnosis and prompt treatment are considered as "preventive" methods (Trobisch et al., 2010). The symptoms of idiopathic scoliosis may become worsen with a delayed diagnosis, making it more difficult to be improved. Not only that, most of the those who has been diagnosed with scoliosis, they are unaware of the fact that this spinal deformity can result in several consequences in addition to the deformity itself. These could be subtle and multidimensional in character, or they could vary depending on the individual (Hudson, 2016). It could have detrimental effects to varying degrees, such as rotation of the pelvis and lower extremities, which could further cause uneven stress on the contralateral lower limbs, patellofemoral instability, asymmetry gait etc. Numerous subsequent compensatory or induced kinematic errors during gait might result from tibial torsion (Hudson, 2016). A significant biomechanical change in the alignment of bone and joint are caused by both internal and external tibial torsion as per literature (Metgud et al., 2022). So, that being the case, a list of assessments as well as free scoliosis diagnosis for UTAR students is conducted to raise awareness in scoliosis among UTAR students and give an opportunity for UTAR students to have early diagnosis and prompt treatment to prevent it from getting worse. Besides, this study

can bridge the knowledge gap and stop students who are unfamiliar with scoliosis from having false beliefs about the condition.

1.7 Scope of Study

This study is mainly focused on determining the tibial torsion and leg length discrepancy in idiopathic scoliosis among UTAR students and further compare between both contralateral sides of the lower limbs to identify the angle difference in the thigh-foot angle as well as the measurement difference in both contralateral lower limb length in idiopathic scoliosis individuals.

CHAPTER 2

LITERATURE REVIEW

2.1 Scoliosis

Scoliosis is derived from “skoliosis’, a Greek word which brings the meaning of crooked. It is a complex three-dimensional spine deformity marked by a lateral deviation of at least 10 degrees with vertebral rotation and usually associated with a reduction in normal kyphotic curvature of the spine (Hypokyphosis).

Scoliosis is common around the world. There are several studies revealed on the prevalence of scoliosis in different countries. A meta-analysis revealed that the prevalence of scoliosis among primary and middle-school students in Mainland China was 1.02% (Fong, Cheung, Wong, Wan, Lee, Lam & Luk, 2015). According to a study conducted in Singapore among children who aged between 6 to 17, the prevalence rate was found from 0.1% to 3.12% according to the respective categorized age groups (Daruwalla, Balasubramaniam, Chay, Rajan & Lee, 1985). Another study which was conducted in Mainland China report an overall scoliosis prevalence rate of 5.14% whereby a total of 99,695 children were screened for the study (Hengwei, Zifang, Qifei, Weiqing, Nali, Ping & Junlin, 2016). A large series of school screening study which was conducted in Malaysia reported the prevalence rate of scoliosis was 2.55% (Deepak et al., 2017). In El-Gendy et al., (n.d.) study,

they revealed the prevalence rate of scoliosis in Taif University female students in India. A total of 200 female volunteers' students who aged between 18-24 years old were enrolled in this study. The results showed that the prevalence rate of postural scoliosis and idiopathic scoliosis were 13.5% and 6% respectively (El-Gendy, Gharib, Ahmed & Koura, n.d.). In previous regional and population-based studies, the prevalence was found in the range between 1% and 13% due to different socioeconomic and environmental factors (Soucacos, Soucacos, Zacharis, Beris & Xenakis, 1997; Daruwalla et al., 1985; Fong et al., 2015; Hengwei et al., 2016). Even though the findings in the prevalence of scoliosis in different countries and age group was varied to each other, scoliosis is still considered as a common spinal deformity condition which is encouraged to study more, as well as its outcome measures.

2.2 Classification of idiopathic scoliosis

Idiopathic scoliosis is diagnosed only when there is a lack of unambiguous evidence for a particular etiology in the history, clinical, and radiological data (Trobisch et al., 2010). The age of the patient at the time of the diagnosis is the determinant of the idiopathic scoliosis classification. Based on the idea that three growth spurts correlate to the phases of greatest risk for scoliosis severity, the condition is divided into three sub-groups, which are the infantile scoliosis (under 3 years old), juvenile scoliosis (3-9 years old) and adolescent scoliosis (10-18 years old). Adult scoliosis affects individuals over the age of 18 (Trobisch et al., 2010; Fletcher & Bruce, 2012). The level of maximal spinal curvature (thoracic,

thoracolumbar, or lumbar) and the convex side (right-convex or left-convex) are helpful features for scoliosis clinical description (Trobisch et al., 2010). King and Lenke academic classification schemes which classify idiopathic scoliosis into 5 or 6 major categories respectively depending on the curvature pattern are found in most of the papers (King, Moe, Bradford & Winter, 1983; Lenke, Betz, Harms, Bridwell, Clements, Lowe & Blanke, 2001).

2.3 Physical examination

A baseline evaluation of curve patterns, shoulder levels, waist asymmetries, and pelvic tilt should be included in a physical examination. Clinically, the Adam's forward bend test should be used to assess rib rotational deformity (rib hump). A rib hump on the convex side of the curve would indicate a positive test result. The use of Adam's forward bend test for scoliosis screening is questioned in Karachalios et al. (1999) study. A total of 2700 students who are aged between 8 and 16 years from Samos Island were screened for scoliosis in 1987. A total of 153 students were found to have spinal deformity. The Adam's forward bend test was included as one of their screening techniques in the 10-year clinical and radiologic follow-up. Based on their results, Adam's forward bend test showed false-negative results in 5 cases for 84.37% sensitivity and 93.44% specificity. As compared to other techniques, Adam's forward bend test had a comparatively lower negative predictive value. They concluded that Adam's forward bend test cannot be acknowledged as a reliable diagnostic standard for the early detection of scoliosis,

particularly when it is the only screening technique used because it yields an undesired number of false-negative findings.

The scoliometer is one of the several non-invasive, radiation-free techniques that have been suggested as an indicator of scoliotic abnormalities (Knott, Pappo, Cameron, deMauroy, Rivard, Kotwicki, Rigo, 2014). The study by Coelho et al., 2013 revealed that there was a good correlation between the scoliometer measurements and the radiographic measurements. Their objectives included measuring the intra- and interrater reliability of the scoliometer measurements, identifying the correlation of the values in the scoliometer measurements with the Cobb angles in the radiograph and evaluating the sensitivity and specificity of the scoliometer measurements for various idiopathic scoliosis diagnosis criteria. The intra-rater and inter-rater reliability were both 0.92 and 0.89 respectively. A total of 64 participants with 32 idiopathic scoliosis patients were enrolled in the study. To obtain the data for the reliability values, an average of 3 times measurements of the 17 spinal levels in a relaxed forward bending position using a scoliometer were taken whereas the sensitivity and specificity were evaluated using the highest trunk rotation value which were then compared with the Cobb's angle in the radiograph. The referral criteria for radiograph were a 10° of Cobb's angle and axial trunk rotation values range from 5° to 10°. The findings revealed excellent intrarater reliability values and very good interrater reliability values. The radiograph analyses and scoliometer measurements had a satisfactory

(r=0.7, p<0.05) correlation and an 5° axial trunk rotation showed the highest sensitivity value at 87%.

According to another study conducted by Trobisch and his colleagues in 2010, Adam's forward bend test had been discovered to be one of the efficient screening techniques. The cut-off point for referral for scoliosis examination is typically 7° of rotatory asymmetry as measured by a scoliometer. Scoliometer readings of 7° corresponds with a 20° Cobb angle (Bunnell, 1984). Thus, Adam's forward bend test along with a scoliometer measurement was used in this study as a screening tool for detection of scoliosis on its high reliability and sensitivity which have been proven in the previous study.

2.4 Body Mass Index (BMI)

BMI is considered as a confounding factor at which early clinical signs of scoliosis in high BMI individuals are much more difficult to be detected (Grivas, Burwell & Dangerfield, 2013). A study by Margalit et al., 2017 reported that obese patients had a larger mean major curve of 44° than normal-weight patients of 34° (P = 0.004). It concluded that larger thoracic curves were presented in obese patients as compared to normal-weight patients. Scoliometer measurements for a given rotational deformity may be affected by the differences in chest-wall thickness in patients with various BMI values. Based on the BMI values, their findings recommend new referral criteria for the scoliometer test, especially to

patients who are obese, a 5° axial trunk rotation value should be referred (Margalit, McKean, Constantine, Thompson, Lee & Sponseller, 2017). However, BMI is not important for etiology, but clinical examination.

In 2016, a cross-sectional study on the correlation between calcaneal eversion, tibial torsion and Q angle among normal, overweight and obese individuals was done by Heggannavar and his colleagues. A total of 60 subjects enrolled in the study and their findings reported a significant difference in tibial torsion between normal-overweight ($p=0.001$) and normal-obese ($p=0.031$) on the right side (Heggannavar, Battula & Metgud, 2016). Tibial torsion was varied in individuals with different BMI. Therefore, BMI is considered as one of the confounding factors in tibial torsion.

2.5 Tibial Torsion (TT)

Tibial torsion refers to any twisting of the tibia along its longitudinal axis that results in an alteration of the alignment of the planes of motion of the proximal and distal articulations (Hutter & Scott, 1949). It has been defined as the angle formed by the articular axis of the knee and ankle joints (Kristiansen, Gunderson, Steen & Reikerås, 2001). Tibial torsion is one of the crucial anatomical parameters and it varies in every individual. These changes are particularly relevant in the perspective of alignment guidelines which includes the rotational landmarks of the tibia (Gandhi et al., 2014). Tibial torsion is clinically significant because severe

degrees of tibial torsion are typically evidenced by gait abnormalities characterized by in-toeing and out-toeing.

Internal tibial torsion refers to internal rotation movement of the tibia (Sielatycki, Hennrikus, Swenson, Fanelli, Reighard & Hamp, 2016). The extent of torsional deformity can be determined by the measurement of tibial torsion. Tibial torsion is measured through various methods. There is no standard measurement found in the literature for measuring tibial torsion (Kristiansen et al., 2001). One of the reliable methods is measurement of thigh foot angle which have been reported in previous studies (Stuberg et al., 1991; Lee et al, 2009; Singh, Gupta, Kaur & Sharma,2022). Thigh-foot angle values typically ranges from 5° to 30°, with negative angles pointing towards the midline and positive angles pointing away from the midline (Staheli, Corbett, Wyss & King, 1985). Internal tibial torsion which is measured by a thigh foot angle of less than -15° after the age of 8 may lead to functional difficulty, toeing-in and bowlegs in severe persistent tibial torsion cases (Sielatycki et al., 2016). Excessive tibial torsion may cause crouch gait whereby the muscle's ability to extend the hip and knee during walking is impaired (Hicks et al., 2007). The range for a normal tibial torsion is between 13° and 18°. A tibial torsion of less than 13° was considered to be internal tibial torsion and external tibial torsion was defined as greater than 18° (Metgud et al., 2022).

A study on the prevalence of tibial torsion was done in India (Gandhi et al., 2014). The objectives of the study were to give a baseline data on the angle of tibial torsion among Indian population. Based on Gandhi et al. (2014), results from 100 adult Indian dry tibial bones (50 women, 50 men) showed that the tibial torsion of the right tibia ranged from 20.00°-37.00° in males and 15.00°-38.00° in females. Meanwhile on the left tibia, the tibia torsion of males ranged from 20.00°-40.00° in males and 20.00°-37.00° in females. The authors reported that the study's findings are particularly significant in view of technological advances in orthopedic reconstructive surgical treatments. Another cross-sectional study conducted by Karukunchit et al., 2015 was done with 249 rice farmers in Thailand with the aim to determine the prevalence and risk factors of lower extremity malalignment in the population of rice farmers. The results from the study reported the prevalence of tibial torsion among Thai rice farmers is 21.29%. One of the risk factors for leg length discrepancy is age (Karukunchit et al., 2015).

Burwell and his colleagues have discovered significant proximal-distal lower limb skeletal disproportion, abnormal torsional movements and other skeletal disproportion are common in adolescent idiopathic scoliosis (AIS) participants (Burwell, Aujla, Kirby, Moulton, Dangerfield, Freeman & Webb, 2008). In 2008, Burwell and his colleagues conducted a study to measure femoral anteversion and tibial torsion using real-time ultrasound. A total of 78 children were examined. The result showed that there is no significant difference between male and female. However, the findings (mean & SD, girls $6° \pm 8°$, $p > 0.001$; boys $5° \pm 7°$, $0.001 <$

P < 0.01) revealed there was asymmetry of tibial torsion, greater on the right side in both genders. The right tibial mean SDS of +0.32 in AIS group was significantly greater as compared to the control group (mean -0.04, p=0.04). As to the left tibial, there was no significant difference between two groups. In short, there was tibial torsion asymmetry between both genders in AIS subjects. Torsional abnormalities which were expressed in both femoral and tibial growth plates suggest that similar torsional abnormalities in the vertebral growth plates is possible in causing deformity of AIS (Burwell et al., 2008).

In 2018, Márkus and his colleagues studied on the effect of coronal decompensation on the biomechanical parameters in lower limbs in AIS. The aim of their study was to investigate if there is a change in the lower limb bone anatomy using 3D imaging methods. They aimed to identify which features of the deformity contribute the greatest effect on the lower limb biomechanical parameters in AIS. In this study, Electro-Optical System (EOS) images of 280 AIS and 56 controls were selected randomly. The Kolmogorov-Smirnow test, *t*-test and linear regression analysis were implemented during the statistical analysis. A p value < 0.05 was significant. Based on the findings, tibial torsion and total lower limb length showed significant difference between contralateral sides among the 15 examined lower limb parameters, but no significant difference was found between sides in the control group.

2.6 Leg Length Discrepancy (LLD)

Leg length discrepancy refers to a condition in which noticeably unequal length in the paired lower extremity limbs (Gurney, 2002). This condition can be observed in 3-15% of the population. A retrospective study indicated that at least 1 in every thousand people has LLD of more than 2cm (Guichet, Spivak, Trouilloud & Grammont, 1991). Frontal pelvic obliquity and lumbar scoliosis with convexity towards the shorter extremity may be caused by LLD (Raczkowski, Daniszewska, Zolynski, 2010). It is a typical orthopedic condition that can cause stress fractures, low back pain and standing instability. In addition to that are postural deformation and gait asymmetry. Over time, it might eventually lead to structural alterations in the spine (Kobayashi, Ando, Nakashima, Machino, Morozumi, Kanbara, Ito, Inoue, Yamaguchi, Mishima, Ishiguro & Imagama, 2020).

A study conducted by Gordon et al., (2019) revealed that only 10% of participants have lower limbs that are exactly the same length while 90% of them have a limb length difference of less than 1 cm. An increased number of patients with limb length differences > 5mm had hip and knee pathologies (Gordon et al., 2019). There is evidence to suggest that LLD is the root of recurrent biomechanical abnormalities in the lumbar region which may cause long-term degenerative alterations to the vertebral bodies (Sheha et al., 2018). There is no study shown that LLD causes lumbar degenerative scoliosis to occur (Sheha et al., 2018). If LLD ≥ 30mm, it will cause the development of severe scoliosis (Kobayashi et al., 2020). A study to investigate leg length discrepancy in functional scoliosis was done by

Raczkowski and his colleagues in 2010. A total of 369 children with LLD-related functional scoliosis who aged from 5 to 7 years participated in this study. From their findings, adjustment of the spine to new static conditions and correction of the curve were observed between 3 to 24 months. The average time required for a real equalization of the discrepancy was 11.3 months. A conclusion from the study was that LLD < 2 cm was a static disorder (Raczkowski et al., 2010).

A study reported functional LLD but not significant structural LLD were found in adolescent idiopathic scoliosis with $p < 0.001$ (Sekiya et al., 2018). Ploumis et al., 2018 had revealed the prevalence of LLD among idiopathic scoliosis. According to their study, only 8.2% (n=6) of the 73 scoliosis participants had LLD. Another study also revealed that out of 246 scoliotic patients, only 15 of them (6.1%) was diagnosed wih LLD > 1cm (Landauer, 2013).

Knowledge Gap & Limitations

After reviewing numerous relevant literatures, there are limited studies conducted in Malaysia in recent 10 years. Most of the studies are conducted in Western countries at which the data is not able to be applied globally on the reasons of distinct geographical and cultural differences as well as body structures variations (Snow, 2021). According to a study, the body structures between Europeans and Asians are virtually different (Crawfurd, 1867). Apart from that, majority of the studies focused on populations in schoolchildren and adolescents as

well as other conditions, in addition to that, less studies targeted on adult idiopathic scoliosis which is considered as one of the important populations for early detection of scoliosis to avoid severe progression, which may cause various negative changes to the body. As can be seen that most of the information and data in the present studies are referred from articles which was published for more than 10 years of time. Some of the findings may have some conflicts. Other limitations may include some confounding factors like age group, as the lower limbs still developing and BMI which may alter the load of lower limbs. All these factors may contribute bias to the study itself. Thus, the aim of this study is to investigate the tibial torsion and leg length discrepancy in idiopathic scoliosis among UTAR students.

CHAPTER 3

MATERIALS AND METHODOLOGY

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

3.1 Study Design

An analytical cross-sectional under the category of observational study was carried out by surveying on idiopathic scoliosis and healthy individuals among UTAR students to determine the prevalence of tibial torsion and compare the findings in idiopathic scoliosis among UTAR students. Although there were comparisons, no intervention was implemented. Since this study was conducted over a short period of time with no follow-up, examined both exposure and outcome at the same time and identified the association between the exposure and outcome without causality, a cross-sectional study design was used (Setia, 2016). A three-day scoliosis screening program was conducted for data collection. Several booths were set up for scoliosis screening and examining the participant's thigh foot angle, leg length discrepancy and BMI values.

3.2 Study Setting

This study was carried out at the Physiotherapy Centre which is situated at 3rd floor of KA block in Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus in Kajang, Selangor and Block A (A011) in UTAR Kampar Campus in Malaysia. Data collection was begun as soon as authorization was received, and it took 3 days to complete.

3.3 Study Population

The study population was targeted on idiopathic scoliosis students who are currently studying in UTAR Sungai Long and Kampar Campus.

3.4 Sample Size

Krejcie and Morgan (1970) Table (refer to Appendix E) was used in this study to determine the sample size from a given population. Since the population size of students in both UTAR Sungai Long and Kampar campus was 23000, my overall sample size will be 417.

3.5 Sampling Method

This study used convenience sampling method. Convenience sampling method is also known as non-probability sampling method which uses techniques to frequently choose participants from a place, internet site and others. This method is famous as it is inexpensive, consumes less time than other sampling methods and

is straightforward. This study only focused on students residing at UTAR Sungai Long & Kampar campus as it is not very feasible to recruit other university students due to lack of time.

3.6 Inclusion Criteria

Participants will be included:

- Male and female UTAR students between 18-25 years old who has idiopathic scoliosis
- Body mass index of 18.5–22.9 kg/m^2

Individuals who aged between 18-25 years and detected idiopathic scoliosis were included in study. Only individuals whose BMI fell between 18.5 to 22.9 kg/m^2 were eligible for this study as BMI was considered as one of the confounding factors which contributes to the angle of tibial torsion.

3.7 Exclusion Criteria

Participants will be excluded:

- Neurological, congenital, development and miscellaneous scoliosis
- Exhibition of structurally derived curvature and any secondary causes are present
- Done any musculoskeletal system surgery before

Those who had developed neurological, congenital, development and miscellaneous scoliosis were not eligible to participate in this study. Individuals who exhibit structurally derived curvature and any secondary causes are present were excluded in this study. Individuals who had undergone any musculoskeletal surgery previously were excluded as this study aims to determine the tibial torsion, thigh foot angle and leg length discrepancy before any treatment was given.

3.8 Instrumentation

1. Scoliometer

Scoliometer is used in this study to determine the presence of idiopathic scoliosis among UTAR students. The scoliometer's measurement accuracy has been rated from competent to good (Coelho, Bonagamba & Oliveira, 2013) and its measurement validity when associated with the Cobb angle has been rated from very good to exceptional. In other words, rather than being examined for accuracy in measuring the angle in degrees, as is the case with validity, the validity of this tool has been evaluated for its ability to detect the presence of scoliosis (Vidal, Ilharreborde, Azoulay, Sebag & Mazda, 2013). According to Coelho et al., 2013, the intra-rater and inter-rater reliability were both 0.92 and 0.89 respectively which is highly reliable.

2. Goniometer

Goniometer is used to measure the participants thigh foot angle in this study. The Cronbach α values for goniometer is greater than 0.99 which revealed high reliability (Jaeger et al., 2007). The degree of discrepancy may not have a significant clinical impact because the margin of error for goniometric measurements is typically reported to be in the range within 5°. The goniometric technique described by Staheli and investigated in his study offers the clinicians a reliable screening tool that does not need specialized equipment or expose patients to radiation and the results are repeatable within a reasonable range (Staheli & Engel, 1972). Before each measurement is taken, the reading on the goniometer is adjusted to zero for higher accuracy level.

3. Human Body Weighing Machine Analog Weight Scale with Height Rod

The height and weight of the participants are measured by using a human body weighing machine analog weight scale with height rod to calculate BMI in this study. Seca 7691321004, 769 digital column scale with BMI function and telescopic measuring rod seca 220 is used. To ensure a higher level of accuracy, calibration is done where the reading is adjusted to zero before measuring each participants' weight.

4. Measuring tape

In this study, measuring tape is used to measure the leg length of the contralateral lower limbs to determine leg length discrepancy (LLD). Using a measuring tape to measure the length of the leg from medial malleolus to the anterior superior iliac spine (ASIS) is valid and reliable. Consequently, it is accurate in clinical measures (Gogia & Braatz, 1986). Another study indicates that using tape measure method (TMM) to derive leg length discrepancy measurements are valid determinants of leg-length inequality (Beattie, Isaacson, Riddle & Rothstein, 1990).

3.9 Procedure

After the ethical approval by the UTAR Scientific and Ethical Review Committee was received, a scoliosis screening program was conducted for data collection. A Google form including consent form (refer to Appendix D) and demographic questions were prepared and then distributed to UTAR students through poster, social media apps which includes Facebook, Instagram, WhatsApp, We Chat, Telegram, Twitter, Microsoft Team and UTAR email. A QR code of the google form was created as well. The participants then clicked the "Submit" button after they filled up all the questions in the Google form to hand in the responses for registration. The first two days of the screening program were carried out in UTAR Sungai Long campus while the venue for the third day of screening program was in UTAR Kampar Campus. Throughout the screening program, several booths were set up at Physiotherapy Centre which is situated at 3rd floor of KA block in

Universiti Tunku Abdul Rahman (UTAR) in Sungai Long in Kajang, Selangor and Block A (A011) in UTAR Kampar Campus in Malaysia respectively. The convenience sample of participants who meet the inclusion criteria was recruited to the study. An assessment form (refer to Appendix F) and briefing on the procedures were given face to face to the recruited participants. All the participants were requested to fill in their personal details in the assessment form before the assessments. Adam's forward bending test, scoliometer measurement, height and weight measurement, leg length discrepancy measurement and thigh foot angle measurement were the outcome measures which were performed in respective booths. Each booth had one examiner respectively to take the measurement to increase the accuracy of the data.

All the volunteered participants were screened with Adam's forward bending test to detect structural or functional scoliosis (Physiopedia, n.d.). The participants were instructed to bend forward at the waist until the spine is horizontal with the ground with his feet placed together, knees are straight and arms freely hanging forward, palms together, finger pointing towards the ground (Hengwei et al., 2016). The examiner stood behind the participant to check for any contour asymmetry, which is characterized by one side of the back is higher than the other. Any notable clinical signs were recorded.

If there was any asymmetry of the trunk being detected in the Adam's forward bend test, the angle of vertebral rotation was measured using a scoliometer. The scoliometer was positioned perpendicular to the long axis of the torso and moved along the spinal vertebrae at the thoracic, thoracolumbar and lumbar region while the participant bends forward (as in the Adam's forward bend test). The location of the maximal asymmetric prominence and the corresponding angle such as the amount of deviation of the central ball from the midline on the scoliometer were recorded (Burton, 2013).

By using a human body weighing machine analog weight scale with height rod, the weight and height of the participants were measured to calculate the body mass index. Leg length of the contralateral lower limbs to determine leg length discrepancy (LLD) was measured using a measuring tape with the participant lied supine on a couch. The leg length from anterior superior iliac spine (ASIS) to medial malleolus for both contralateral lower limbs was measured and recorded (Gogia & Braatz, 1986). The leg length from umbilicus to medial malleolus for both sides of the lower extremities was measured and recorded as well. Thigh foot angle which was one of the methods of tibial torsion measurement was examined with participant in a prone position, knee in 90-degree flexion, ankle in neutral alignment, the volar aspect of the foot is parallel to the ground and the heel at the edge of the couch. At this position, the angle between the longitudinal axis of the thigh and foot was calculated. This method of measurement was performed using a

standard goniometer which has an arm length of 18 cm and uses 1 increment (Lee et al., 2009).

Data coding and analyzing were started soon after the collected data had been checked and finalized to make sure there was no missing pieces and errors as well.

3.10 Statistical Analysis

In this study, all the collected data were computed and analyzed through a software, namely IBM Statistical Package for the Social Sciences (SPSS) Statistics 28.0 and Microsoft Excel to generate the study findings. Descriptive analysis was used to convert raw data into a more understandable and analyzable format after which descriptive information was generated (Zikmund et al., 2003). Demographic data in this study including gender, height, and weight were analyzed using descriptive statistics to provide frequency and percentage for categorical variables or mean and standard deviation for continuous variables. Paired *t*-test was used to evaluate tibial torsion by analyzing the TFA between the contralateral sides of the lower limbs in idiopathic scoliosis among UTAR students.

3.11 Ethical Approval

This study was subjected to the ethical approval by the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman (UTAR) to ensure that the research was carried out in a responsible and ethical manner. An

ethical approval letter was provided after the approval and it was attached in Appendix A. The PDPA statement, information sheet and consent form which contained the introduction of the research were given to the participants for signing (refer to Appendix B, Appendix C and Appendix D). The collected information was kept confidential. Participants also had the option to stop participating in the study at any time. All the participants' records and information were secured using password-protected files. Apart from myself to use the collected data for analyzing purpose, their information was kept confidential. All of these considerations were critical to safeguard the research participants' rights, improve research validity and preserve scientific integrity.

CHAPTER 4

RESULTS

This chapter features the findings and statistical analysis after the data collection process for the research project. Demographic data of the participants will be presented first, followed by the score and grouping of the outcome measures, results of the inferential tests and hypothesis testing. The results will be presented in the sequence of the relevant graphs, if any and followed by a brief description and lastly the tabulation at the end of that component.

4.1 Demographic Data of the Participants

With 3 days of data collection, a total of 202 participants were successfully recruited via social media (WhatsApp, Facebook, Instagram), Microsoft Team, Email and by face-to-face approach by responding to the online registration form. Out of the 202 participants, 171 of them who did not meet the inclusive criteria and another 2 participants who met the exclusion criteria were excluded from this study. These data were removed from the data analysis process. As a result, only 29 participants' data were proceeded to data analysis through SPSS version 28.0 software.

The frequency and percentage or mean and standard deviation for demographic data including gender, height and weight of all the participants are illustrated in Table 4.1 below.

Table 4.1: *Demographic Data of Participants*

Variables	**Frequency (%)**	**Mean (SD)**
N	29 (100)	
Gender		
Male	15 (51.7)	
Female	14 (48.3)	
Height		1.67 (0.079)
Weight		56.83 (6.603)

Note: N = Total number of participants

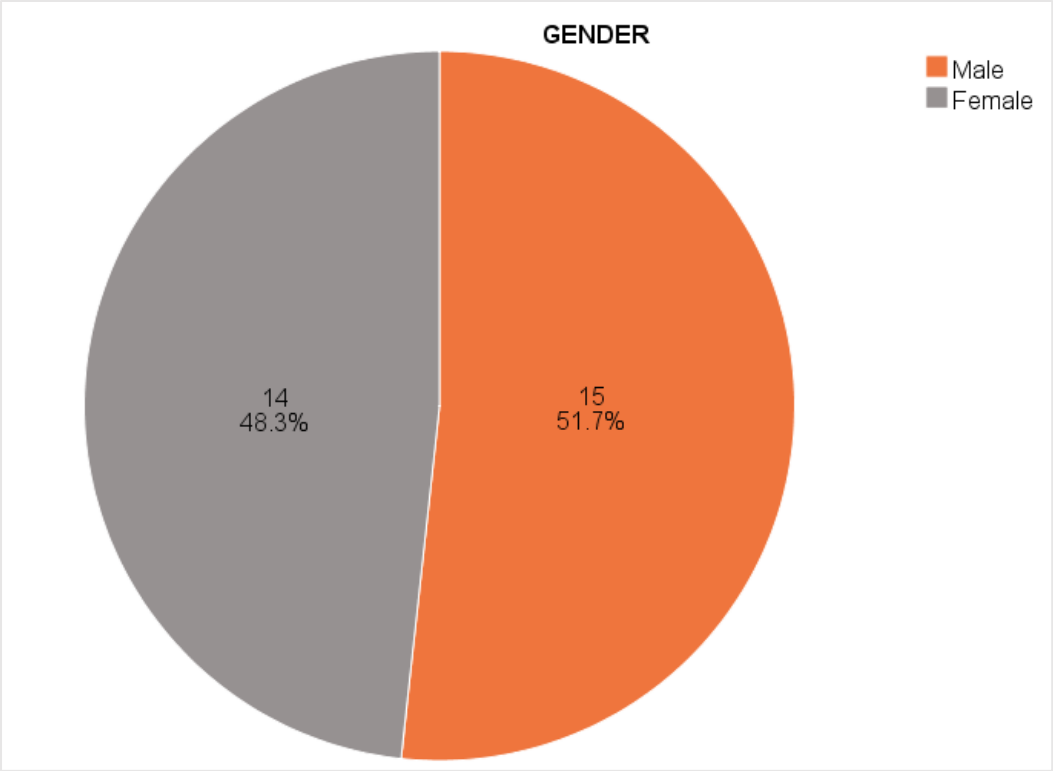

Figure 4.1: *Gender of Participants*

Referring to the demographic data of participants in Table 4.1, the average height of the participants was 1.67 with standard deviation of 0.079 meters. The average weight of the participants was 56.83 with standard deviation of 6.603 kilograms.

Figure 4.1 above illustrates the gender of participants in this study. Among 29 participants (100%), 15 of them was male which make up 51.7% and 14 female was accounted for 48.3%.

4.2 Prevalence of Tibial Torsion

4.2.1 Thigh Foot Angle Findings

The prevalence of tibial torsion among the participants was investigated and determined through thigh foot angle in current study. Data collected were used to calculate the thigh foot angle distribution which classified the participants' tibial torsion into respective categories. The mean and standard deviation for thigh foot angle as well as the frequency and percentage for categories of tibial torsion of all the participants are illustrated in Table 4.2 below.

Table 4.2: *Thigh Foot Angle Findings*

Variables	**Frequency (%)**	**Mean (SD)**
N	29 (100)	
Average Thigh Foot Angle		11.40 (4.844)
Left		10.65 (5.278)
Right		12.12 (5.200)
Average Tibial Torsion		
Internal	17 (58.6)	
Normal	11 (37.9)	
External	1 (3.4)	
Left Tibial Torsion		
Internal	19 (65.5)	
Normal	7 (24.1)	
External	3 (10.3)	
Right Tibial Torsion		
Internal	14 (48.3)	
Normal	12 (41.4)	
External	3 (10.3)	

NOTE: N = Total number of participants

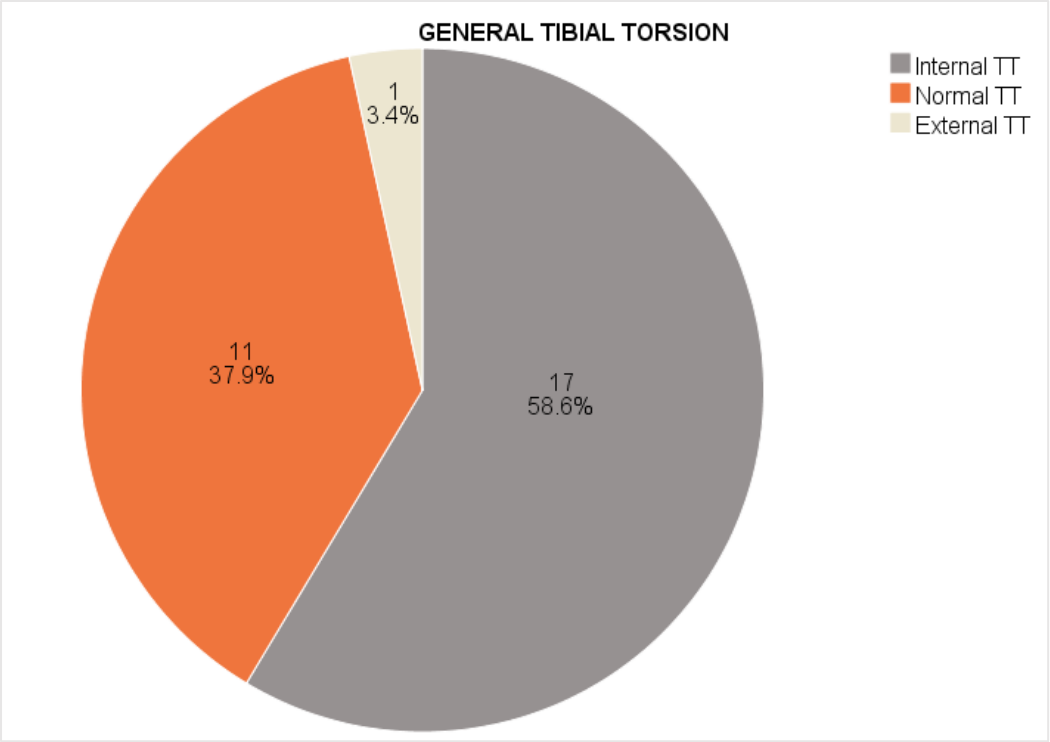

Figure 4.2: *General Tibial Torsion of Participants*

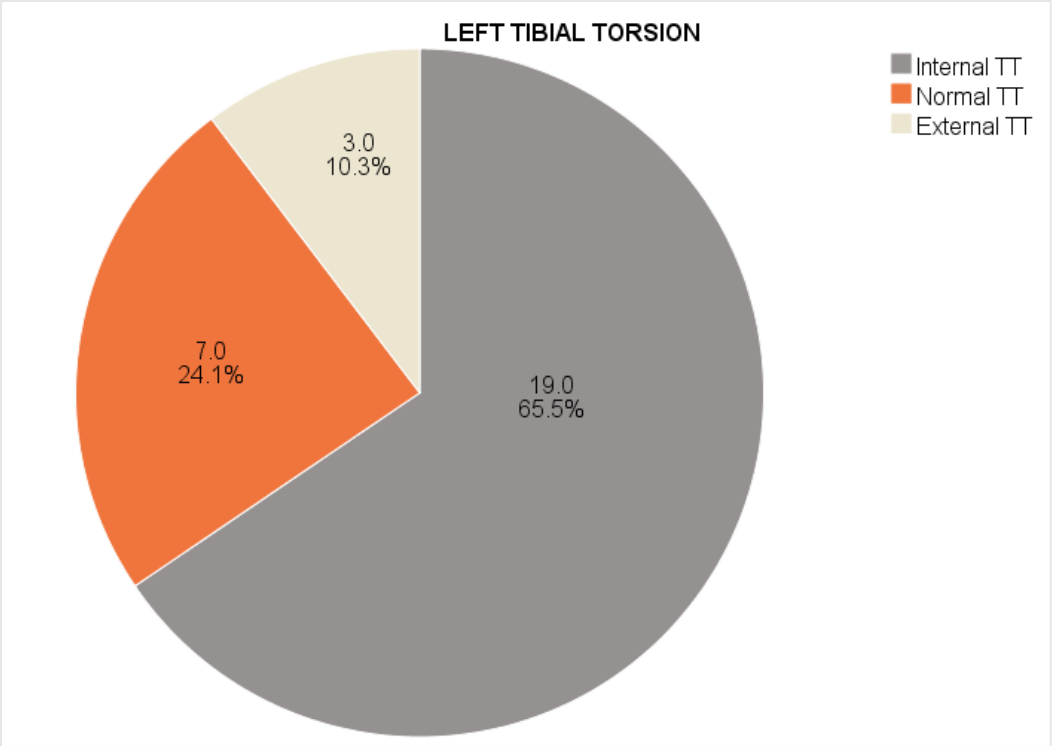

Figure 4.3: *Left Tibial Torsion of Participants*

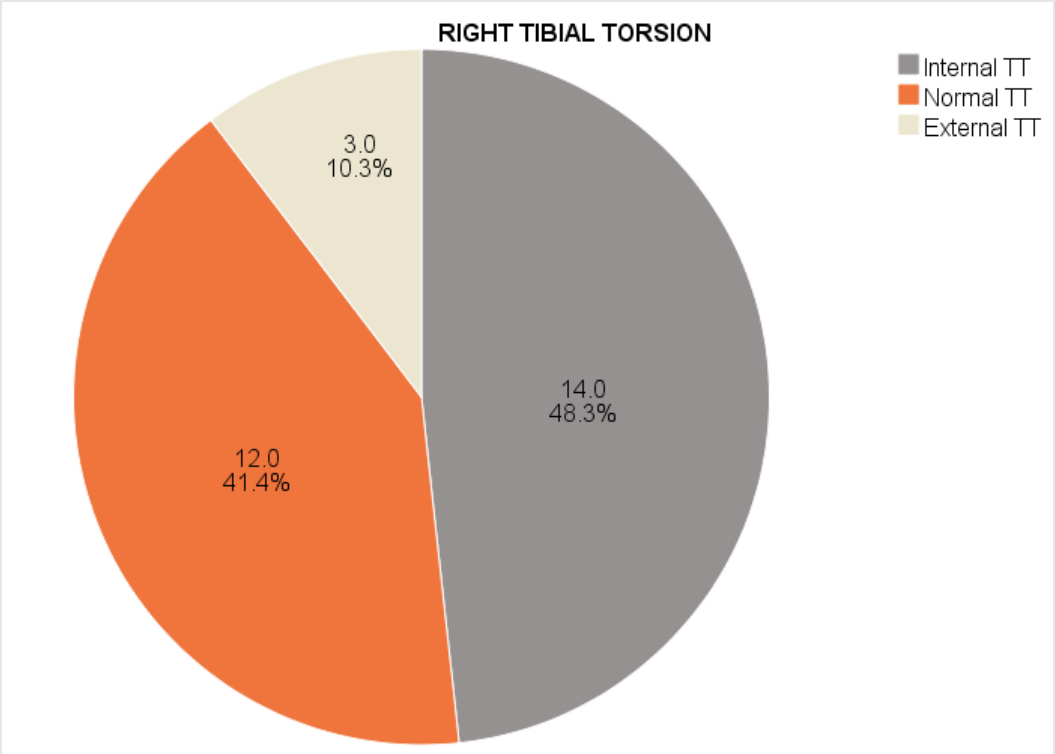

Figure 4.4: *Right Tibial Torsion of Participants*

Table 4.2 demonstrates the mean and standard deviation of thigh foot angle of the participants. The general thigh foot angle in 29 participants (100%) was reported 11.40° (SD: 4.844). The average left thigh foot angle of the participants was 10.65° with a standard deviation of 5.278 and the average right thigh foot angle was 12.12° with a standard deviation of 5.2.

Figure 4.2 illustrates the findings for average tibial torsion of the participants which includes internal, normal and external tibial torsion. The participants who had internal, normal and external tibial torsion were 17 (58.6%), 11 (37.9%) and 1 (3.4%) accordingly.

Figure 4.3 above displays the findings for left tibial torsion of the participants. There were 3 categories for left tibial torsion which representing internal, normal and external tibial torsion respectively. Out of 29 participants, a slightly higher in number, 19 (65.5%) was indicated in internal tibial torsion, followed by normal tibial torsion with 7 (24.1%) and external tibial torsion 3 (10.3%).

Figure 4.4 shows the findings of right tibial torsion in 29 participants. Internal, normal and external tibial torsion represented 3 respective categories of tibial torsion. Among the 29 participants, 14 (48.3) participants had external torsion of the right tibia while 12 (41.1%) participants were in the normal tibial torsion category. The number of participants in the external tibial torsion category was comparatively lesser than the other two categories, which was 3 (10.3%).

4.2.2 Tibial Torsion Findings Based on Gender

Table 4.3: *Tibial Torsion Based on Gender*

	Gender	
	Male (%)	Female (%)
N	15 (100.0)	14 (100.0)
Average Tibial Torsion		
Internal	10 (66.7)	7 (50)
Normal	4 (26.7)	7 (50)
External	1 (6.7)	0 (0)
Left Tibial Torsion		
Internal	10 (66.7)	9 (64.3)
Normal	2 (13.3)	5 (35.7)
External	3 (20.0)	0 (0)
Right Tibial Torsion		
Internal	7 (46.7)	7 (50.0)
Normal	7 (46.7)	5 (35.7)
External	1 (6.7)	2 (14.3)

Note: N = Total number of participants

Tibial torsion among different gender of 29 participants are presented in Table 4.3 above. The number of male female participants was 15 and 14 respectively. The study findings of tibial torsion among the male participants reported the number of male participants who had internal torsion of the tibia was the highest, with 66.7% (n=10), followed by normal tibial torsion with 26.7% (n=7) and external tibial torsion with 6.7% (n=1). Meanwhile, tibial torsion in female participants showed similar percentages of 50% (n=7) in internal and normal tibial torsion. From the table above, it showed none of the participants had external torsion of the tibia.

66.7% (n=10) of the participants, which had the highest percentage among all of the tibial torsion groups, were male in internal tibial torsion group of the left lower extremity. Among the 15 male participants, 13.3% (n=2) and 20.0% (n=3) of them were found to have normal and external tibial torsion respectively. Meanwhile, 64.3% (n=9) and 35.7% (n=5) of the female participants were in internal and normal tibial torsion groups of the left lower extremity accordingly. None of the female participants found to have external torsion of the left tibia.

After categorizing all the participants into different groups of tibial torsion, it was noticed that there was similar percentage of male participants having internal and normal tibial torsion of the right lower extremity, which was 46.7% (n=7). There was only 6.7% (n=1) of the participants having right external tibial torsion. In female participants, the percentage of participants in the group of right internal, normal and external tibial torsion was 50.0% (n=7), 35.7% (n=5) and 14.3% (n=2) accordingly.

4.2.3 Tibial Torsion Findings Based on Height

Table 4.4: *Tibial Torsion Based on Height*

	Height Mean (SD)
Average Tibial Torsion	
Internal	1.68 (0.084)
Normal	1.65 (0.062)
External	1.80 (0)
Left Tibial Torsion	
Internal	1.68 (0.075)
Normal	1.66 (0.089)
External	1.68 (0.089)
Right Tibial Torsion	
Internal	1.66 (0.082)
Normal	1.71 (0.044)
External	1.65 (0.097)

Table 4.4 illustrates the tibial torsion groups of the participants based on their height. The mean height of the participants in the group of internal, normal and external tibial torsion were 1.68 (SD: 0.084), 1.65 (SD: 0.062) and 1.80 (SD:0) accordingly. For tibial torsion of the left lower extremity, participants who were in the internal, normal and external tibial torsion groups had a mean height of 1.68 (SD: 0.075), 1.66 (SD: 0.089) and 1.68 (SD: 0.089) in meters. For tibial torsion of the right lower extremity, the highest mean height was in the normal tibial torsion group, followed by internal and external tibial torsion group with the mean height of 1.71 (SD: 0.044), 1.66 (SD: 0.082) and 1.65 (SD: 0.097) respectively.

4.2.4 Tibial Torsion Findings Based on Weight

Table 4.5: *Tibial Torsion Based on Weight*

	Weight Mean (SD)
Average Tibial Torsion	
Internal	57.41 (6.205)
Normal	54.37 (4.875)
External	74 (0)
Left Tibial Torsion	
Internal	56.97 (5.879)
Normal	54.00 (7.122)
External	59.80 (7.597)
Right Tibial Torsion	
Internal	55.73 (6.171)
Normal	59.56 (4.756)
External	55.09 (8.143)

Table 4.5 demonstrates the tibial torsion groups of the participants according to their weight. From the table, the mean weight of participants from the internal, normal and external groups were 57.41 (6.205), 54.37 (4.875) and 74 (0) respectively. Based on the table above, participants who had the highest mean weight of 59.80 with standard deviation of 7.597 fell in the group of external tibial torsion of the left lower extremity. Meanwhile, participants who were in the left normal tibial torsion group had the lowest mean weight, which was 54.00 (SD: 7.122). For the group of left internal tibial torsion, the participants had the mean weight of 56.97 with standard deviation of 5.879 in between the group of normal and external tibial torsion group.

Participants who had normal tibial torsion of the right lower extremity had the highest mean weight of 59.56 with standard deviation of 4.756, followed by the participants who had internal and external tibial torsion of the right lower extremity with the mean weight of 55.73 (SD: 6.171) and 55.09 (SD: 8.143) respectively.

4.3 Inferential Analysis

4.3.1 Comparison of Common Thigh Foot Angle between Both Contralateral Lower Extremities

This subsection will outline the inferential analysis conducted for this study which includes Paired-Samples T test. Paired-Samples T test will be used to compare the common thigh foot angle between both contralateral lower extremities by determining the mean difference.

Table 4.6: *Results of Paired-Samples T Test on Comparison of Common Thigh Foot Angle between Both Contralateral Lower Extremities*

	Left	Right	Diff	Sig
Thigh Foot Angle	10.65 (5.278)	12.12 (5.200)	1.48	0.055

Note: Diff = mean difference; Sig = *p* value

Table 4.6 shows the results of Paired-Samples T test on comparison of common thigh foot angle between both contralateral lower extremities. As presented in the table above, the mean thigh foot angle for left lower extremity was 10.65 with standard deviation of 5.278 and right lower extremity was 12.12 with standard deviation of 5.200. On comparison between both contralateral sides, it was found to be greater on the right side to the left side. The mean difference between left and right thigh foot angle was detected 1.48, *t* value of 2.002 and a *p* value of 0.055 which is greater than 0.05. Since $p > 0.05$, this indicates that the null hypothesis was failed to reject. Thus, there is no significant difference in thigh foot angle between both lower extremities in current study.

4.4 Leg Length Discrepancy

4.4.1 LLD Findings

Leg Length Discrepancy among the participants was investigated and determined through true and apparent leg length differences. Data collected were used to classify the participants into respective categories, either presence or absence of true or apparent LLD. The mean and standard deviation for true and apparent leg length differences as well as the frequency and percentage for categories of LLD of all the participants are illustrated in Table 4.7.

Table 4.7: *Findings of LLD*

Variables	**Frequency (%)**	**Mean (SD)**
N	29 (100)	
True Leg Length Differences		0.81 (0.706)
Apparent Leg Length Differences		0.47 (0.364)
True LLD		
Presence	1 (3.4)	
Absence	28 (96.6)	
Apparent LLD		
Presence	0 (0.0)	
Absence	29 (100)	

Note: N = Total number of participants; LLD = Leg Length Discrepancy

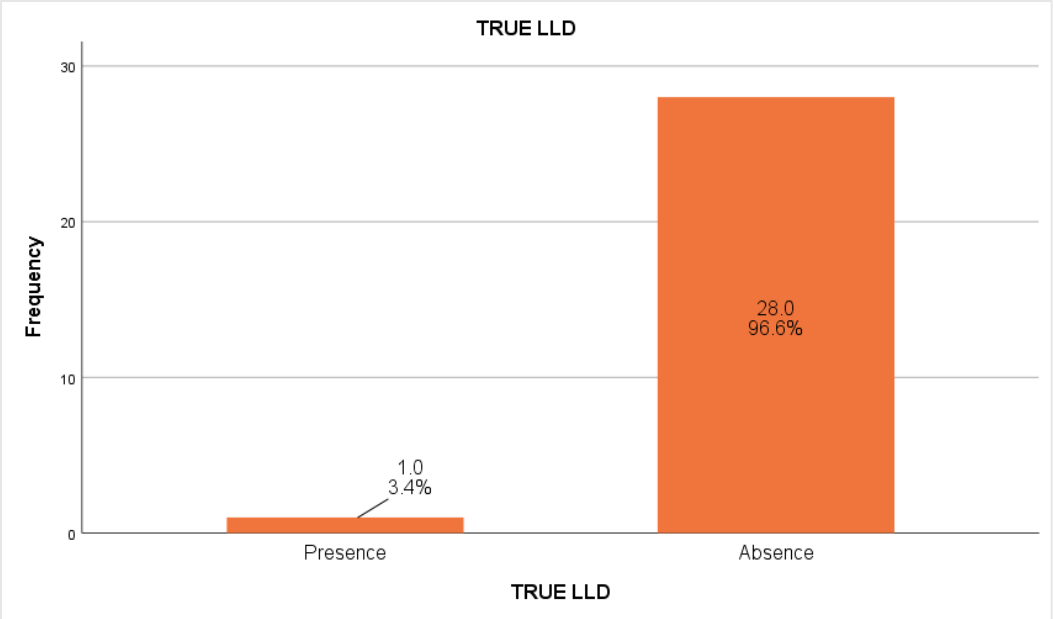

Figure 4.5: *True LLD of Participants*

Figure 4.6: *Apparent LLD of Participants*

Table 4.7 displays the mean and standard deviation of true and apparent leg length differences of the participants. Among the 29 participants, the mean of true leg length differences achieved 0.81cm with a standard deviation of 0.706 while the mean of apparent leg length differences was 0.47cm with a standard deviation of 0.364.

Figure 4.5 demonstrates the findings of true LLD of the participants. The participants are grouped according to the presence or absence of true LLD. Based on the graph above, only 3.4% (n=1) of the participants showed the presence of true LLD. 96.6% (n=28) of the participants did not have true LLD.

Figure 4.6 illustrates the findings of apparent LLD of the participants. There were 2 groups of participants which includes presence and absence of apparent LLD. It clearly showed that none of the participants had apparent LLD. 100% (n=29) of the participants did not have apparent LLD.

CHAPTER 5

DISCUSSION

This chapter will outline the discussion on significant findings from the results sections in accordance with the study objectives, which will follow with the strengths and limitations of study as well as the recommendations for future study.

Only 29 idiopathic scoliosis participants who aged between 18.5-22.9 kg/m^2 were chosen to be included in this study. The ratio of male to female is 15:14. They were selected from participants who do not develop neurological, congenital, development and miscellaneous scoliosis, exhibit structurally derived curvature and presence of any secondary causes and also who did not have any musculoskeletal surgery done previously.

5.1 Prevalence of Tibial Torsion in Idiopathic Scoliosis among UTAR Students

Rotational pathology of tibia had been shown to be as common as 50% among the paediatric population (Fabry et al., 1994). Most of the torsional issues were believed to be corrected upon maturity, leaving some older children and also adults who have cosmetic and functional issue. Tibial torsion was thought to influence 1% of the adult population (Hutter, 1949), while the precise incidence was yet to be determined and there were large geographical variations that make the assessment challenging (Snow, 2021). In adulthood, tibial torsion was poorly

diagnosed and thus it was undertreated (Snow, 2021). Among idiopathic scoliosis, there was no prevalence of tibial torsion being reported before. To the best of researcher's knowledge, this study conducted is among the first to determine the prevalence of tibial torsion in idiopathic scoliosis among university students in Malaysia. In the current study, data for thigh foot angle and tibial torsion of participants aged between 18 to 25 with BMI between 18.5-22.9 kg/m^2 was included and analyzed. In this study, thigh foot angle was used as the measurement of tibial torsion. According to Metgud et al., 2022, internal tibial torsion was deemed when its degree less than 13, while external tibial torsion was considered if its degree greater than 18. From the study findings, the mean thigh foot angle of the participants was 11.40° with standard deviation of 4.844 at which this degree fell in the category of internal tibial torsion. It can be said that among UTAR students with idiopathic scoliosis had internal tibial torsion is more as compared to normal and external tibial torsion. Based on the current study, it reported the prevalence of tibial torsion in idiopathic scoliosis among UTAR students in respective categories which were internal tibial torsion (58.6%, n=17), normal tibial torsion (37.9%, n=11) and external tibial torsion (3.4%, n=1). The prevalence of abnormal torsion of the tibia among the idiopathic scoliosis population was 62% (n=18) in total. The prevalence of tibial torsion in the general population of healthy individuals had never been studied before. As there is no comparison to the healthy group, this study is unable to discuss the risk of tibial torsion in individuals with idiopathic scoliosis. The results of this study only revealed the prevalence of normal and abnormal torsion of the tibia in individuals with idiopathic scoliosis. Sixty two

percent individuals with idiopathic scoliosis in the current study have abnormal tibial torsion which may increase the risk of foot deformities, abnormal gait and knee pathology (Hudson, 2016; Radler et al., 2010; Paulos et al., 2009). However, the findings in current study are not similar to that in Karukunchit et al., 2015 which reported as 21.29% of tibial torsion in Thai rice farmers. It had been established that different populations had varying angles of tibial torsion. As a result, the data collected from other populations may not be applicable to idiopathic scoliosis participants. Gandhi et al., 2014 reported that the results of his study showed that angle of tibial torsion varies greatly between one another. It was left unclear the big difference behind but it might be due to developmental abnormalities or the possibilities of racial influences (Gandhi et al., 2014). Snow et al., 2021 suggested tibial torsion changed over age. As we get older, tibial torsion changed and responded to environmental stimuli and perhaps contributed to or protected against disease, it presumably changed over time. Results reported in Volkmar et al., 2022 suggested age and tibial torsion were not correlated.

Table 4.3 reveals the average findings of tibial torsion where more male participants (n=11) had abnormal tibial torsion as compared to female. The number of male participants with abnormal tibial torsion on the left side (n=13) are more than female. Female participants who had abnormal tibial torsion on the right side (n=9) is slightly more than male. According to Volkmar et al., 2022, there was no correlation between gender and tibial torsion in uninjured subjects. Another study

conducted by Ghandi et al., 2022 reported the mean difference was statistically insignificant although the angle of tibial torsion was more in males on the right side and slightly more in females on the left side.

5.2 Common thigh foot angle between both lower extremities in idiopathic scoliosis among UTAR students

Based on the study findings in Table 4.6, the mean thigh foot angle of the left side was 10.65° with standard deviation of 5.278 whereas the mean thigh foot angle of the right side was reported 12.12° with standard deviation of 5.200. It showed that the angle of tibial torsion in left side was greater away from normal tibial torsion as compared to right side. From the study findings, the difference in mean thigh foot angle for both left and right sides was 1.48° and the *p* value showed was 0.055, slightly greater than 0.05. The findings of the current study were in consonance with the study by Gandhi et al., 2014 where there was difference in the mean values of the angle of tibial torsion between left and right side but the differences were statistically insignificant where p value was greater than 0.05 (Gandhi et al., 2014). However, there were few studies reported significant mean difference of tibial torsion between both contralateral sides of the lower extremities. According to one of the studies which conducted by Márkus et al., 2018 in adolescent idiopathic scoliosis, the *p* value of the side difference in tibial torsion where the left side was compared to the right side, was less than 0.001 which indicated the significant mean difference between left and right tibial torsion of the

lower extremities. In their study, it was found that there was also a significant difference of 1.75° with *p* value=0.003 between contralateral sides in participants who had compensated coronal balance. Another cohort study conducted by Volkmar et al., 2022 revealed an average of 6° difference in tibial torsion between both contralateral sides and 18% of the subjects had a difference of at least 10° was found in 229 subjects without tibial or fibular pathology. Although the result in the current study showed the mean difference of common thigh foot angle between both contralateral lower extremities is insignificant, the *p* value was close to significant. This study could be considered as a preliminary study on thigh foot angle in idiopathic scoliosis, perhaps with a larger sample size of the same population would yield a significant result.

A study by Gandhi et al., 2014 reported the mean angle of tibial torsion on the right and left sides irrespective of sex as 29.38° with standard deviation of 4.95 and 28.06° with standard deviation of 4.58 respectively. Several studies showed difference between contralateral lower extremities (Hutter et al., 1949; Malekafzali et al., 1979; Larson et al., 1983, Clementz, 1989; Eckhoff et al., 1994). The mean readings on the right side were 22.1°, 14.5°, 23.5°, 30.7° (SD: 7.8), 38° (SD:11) and 40° (SD:9) accordingly to the studies mentioned above. Meanwhile, the mean readings on the left side were 19.8° (SD: 0), 14° (SD: 0), 23.1° (SD: 0). 28.6° (SD:7.6), 33° (SD:9) and 32° (SD:10) respectively. Another study reported that more external rotation of right tibia than left tibia (Volkmar et al., 2022). The results of the current study which showed that the majority of

individuals with idiopathic scoliosis had both their tibia internally rotated were contrary to the external rotation of the left and right tibia found in the studies which mentioned previously. Meanwhile, all those studies stated that the mean values which reported with right angle of external tibial torsion was greater than the left angle of external tibial torsion were also in contrary with the current study. Thigh foot angle for internal tibial torsion is likely prevalent on the left tibia in idiopathic scoliosis in present study.

5.3 LLD in Idiopathic Scoliosis among UTAR Students

Scoliosis can be caused by LLD either of reduction in length or excessive growth of one or more bones in the lower extremity or functional issue brought on by unbalanced standing posture and uneven gait (Rose et al., 1999; Kobayashi et al., 2020). From the findings of current study, there was only 1 out of 29 participants who had true LLD (3.4%) and none of the participants present to have apparent LLD. The findings revealed that the prevalence of LLD is low in idiopathic scoliosis population. The findings of current study were in contrary with the study reported by Sekiya et el., (2018) whereby functional LLD but not significant structural LLD were found in adolescent idiopathic scoliosis with $p < 0.001$. Although the correlation test between LLD and idiopathic scoliosis was not done in this study, the findings found in present study was compatible with the findings reported in Ploumis et al., 2018 whereby only 8.2% (n=6) of the 73 scoliosis participants had LLD. Another study revealed that out of 246 scoliotic patients,

only 15 of them (6.1%) was diagnosed wih LLD > 1cm which the study findings were in conjunctive with current study findings (Landauer, 2013). It was believed that LLD is not likely prevalent in idiopathic scoliosis in the current study.

5.4 Significance of the Study

This study which provides a list of assessments as well as free scoliosis diagnosis, offers UTAR students the chance to receive an early diagnosis and prompt treatment if there is any presence of scoliosis detected, to prevent it from getting worse. This study is crucial to raise awareness of scoliosis, tibial torsion and leg length discrepancy among the public as well as those clinicians who treat patients with particular disease or deformity. In clinical setting, the current study establishes a baseline data in the context of the prevalence of tibial torsion and leg length discrepancy in idiopathic scoliosis among university students as well as their common thigh foot angle between both contralateral lower extremities. The study findings are very significant, given the technological breakthroughs in reconstructive surgical treatment used in orthopaedic therapy (Gandhi et al., 2014). For knee surgeons to treat tibial malunions and maltorsions, a precise understanding of the angle of tibial torsion is vital (Gandhi et al., 2014). The knowledge of tibial torsion in this study helps to clarify the pathophysiology of certain relating diseases such as knee osteoarthritis for more effective treatment techniques (Gandhi et al., 2014). Another strength of this study is only those idiopathic scoliosis individuals who have normal BMI are exclusively recruited. This increases the accuracy in the

findings of angle of tibial torsion as BMI is one of the confounding factors which may contribute to the angle of tibial torsion.

5.5 Limitations of the study

The prevalence of idiopathic scoliosis among university students in Malaysia is yet to be unknown, the true sample size is uncertain. The sample size in our study is too small, so we felt this may affect the study findings in detecting significant gender differences and mean difference of tibial torsion between both contralateral sides of the lower extremities. The findings of this study are unable to be generalized due to small sample size. There are only students from 1 university recruited as it is not very feasible to recruit other university students due to lack of time. Another limitation of our study is that the lower limb development is still happening or not among the participants is remained unknown in which with that may affect the consistency and accuracy of the results. Furthermore, it needs to be mentioned that there might be some deviations occur during the direct measurement taking by the examiners.

5.6 Recommendations

To yield a more significant result, a larger sample size of the same population is recommended for future study in relation to current study. As the aim of current study is to determine the prevalence of tibial torsion and leg length

discrepancy in idiopathic scoliosis as well as compare the common thigh foot angle between both contralateral sides of the lower extremity, no causal relationship can be reported. Due to the nature of cross-sectional design, the exact time that each participant's deformities or abnormalities first manifested itself is unknown to us. We do not know the causal relationship in between, so it is unclear whether tibial torsion and leg length discrepancy developed from or prior to idiopathic scoliosis. Lower limb development and the measuring skills of the examiners should be considered by the researcher as the confounding factors in future study. Further study on the association between tibial torsion and other related variables is suggested.

CHAPTER 6

CONCLUSION

In conclusion, this study is the first study to discover tibial torsion measurement among adolescent idiopathic scoliosis. It is documented that tibial torsion influenced 1% among adult (Hutter, 1949). However, it was an old data and to the best of researcher's knowledge, there is no revised data on tibial torsion in adolescent population and how it influences quality of life. Additionally, geographical variations make the data not much applicable to other areas especially, population among UTAR students. Thus, this study shown internal tibial torsion was highly prevalent in idiopathic scoliosis, followed by normal tibial torsion and external tibial torsion. The common thigh foot angle revealed in this study is 11.40°. Being male was shown to have abnormal tibial torsion more than female in comparison. The number of participants with abnormal tibial torsion is compared between gender and were found to be more in males on the left side and slightly more in females on the right side. Study concludes that there is no significant mean difference in common thigh foot angle between both contralateral sides of the lower extremities, but the finding was close to statistically significant where the *p* value found was 0.055, a slightly greater than 0.05. If there is a larger sample size, the representativeness of the sample will be easier to assess and the result interpreted could be significant. However, with the result of the current study, it could be a preliminary database for future thigh foot angle study in adolescent idiopathic

scoliosis. Thigh foot angle for internal tibial torsion is likely prevalent on the left tibia in idiopathic scoliosis. Only 1 out of 29 participants (3.4%) have true LLD. Hence, LLD is not likely prevalent in idiopathic scoliosis. However, no correlation test between LLD and idiopathic scoliosis was done in this study. Future study may conduct correlation test with larger sample size.

These findings reinforce the need for clinicians considering the relationship between tibial torsion and other relevant variables. The possible risks of high thigh foot angle among adolescent idiopathic scoliosis include the increased risk of foot deformities, abnormal in-toeing gait and knee pathology (Hudson, 2016; Radler et al., 2010; Paulos et al., 2009). Future study may conduct possible risks of high thigh foot angle among adolescent idiopathic scoliosis. Since the impact of tibial torsion increases time over time, future studies may think about preventative measures such as raising awareness of the public to reduce the impact of tibial torsion.

CHAPTER 7

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APPENDICES

APPENDIX A

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 Thazhaklattu 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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No	Research Title	Student's Name	Supervisor's Name	Approval Validity
10.	Comparison of Immediate Effect of Soft Tissue Manipulation (STM) and Ice Massage in Mechanical Neck Pain	Wong Hui Lin	Ms Kamala a/p Krishnan	4 November 2022 – 3 November 2023
11.	Association Between Forward Head Posture and Screening Programme of Scoliosis Among UTAR Undergraduate Students	Wong Shi Yi		
12.	Prevalence of Low Back Pain and Its Association with Ergonomic Usage Among UTAR Students	Ian Lee Haorong	Ms Swapneela Jacob Co-Supervisor: Mr Tarun Amalnerkar	
13.	Awareness, Knowledge and Attitude Towards Artificial Intelligence in Learning Among Faculty of Medicine and Health Science (FMHS) Students in UTAR	Hwang Ji Yen		
14.	Awareness & Knowledge of Breathing Exercise as Covid-19 Management Among UTAR Students	Low Wai Kit	Ms Meneka Naidu a/p Mohnaraju	
15.	Awareness on the Adverse Effects of Vaping on Health Among UTAR Students	Lim Yu Hui		
16.	Awareness Towards Bell's Palsy Among University Students	Pong Jia Shan		
17.	The Impact of Ocular Exercises on Headache Symptoms and Sleep Quality Among University Students with Refractive Error	Pea Wan Theng	Ms Kiruthika Selvakumar	
18.	A Study to Analyze the Impact of Balance Exercise Improving Hand to Eye Coordination Among University Students in Selangor	Ong Wesley		
19.	Prevalence of Adolescent Migraine in Malaysia and The Common Triggers for It: A Cross-Sectional Study	Ong Chuu Chyi		
20.	Correlation Between Carrying Angle of Elbow and Upper Limb Flexibility Among Basketball Players	Gienisha a/p Thanapalan	Ms Siti Hazirah Binti Samsuri	
21.	Correlation Between Lower Limb Alignment and Patellofemoral Pain Syndrome Among Badminton Players in UTAR	Hee Ziyu		
22.	Effectiveness of Mindfulness Meditation on Blood Pressure and Resting Heart Rate Among Pre-Hypertensive Young Adults	Toh Jen Min	Mr Imtiyaz Ali Mir	
23.	Comparison of Combined Effect of Aerobic Exercise Training and DASH Diet with DASH Diet Alone on Blood Pressure and Resting Heart Rate Among Physically Inactive Pre-Hypertensive Young Adults	Toh Xue Ying		
24.	Effectiveness of Continuous Moderate-Intensity Training and Mindfulness Meditation on Blood Pressure and Resting Heart Rate Among Physically Inactive Pre-Hypertensive Young Adults	Wan Cai Hui		
25.	Comparison between Inclined Treadmill Sprint Training and Plyometric Exercise in Improving Sprint Performance Among Healthy Young Adults	Jasmine Song WenHui	Ms Premala a/p Krishnan	
26.	Effect of Pilates-Based Exercise on Young Adults with Patellofemoral Pain	Jesslyn Ng Jee Cheng		
27.	Association Between Quadriceps Angle and Hamstring Flexibility with Knee Injuries Among Weight Lifters	Teh Wei Ze	Ms Ambusam a/p Subramaniam	
28.	Knowledge, Awareness and Perception of Prostate Cancer Among Undergraduate in University Tunku Abdul Rahman (UTAR)	Tan Kean Guan		
29.	Prevalence of joint Hypermobility and Association with Musculoskeletal Injuries Among University Students in UTAR	Khor Suky	Mr Nizar Abdul Majeed Kutty	
30.	Association of Social Physique Anxiety with Physical Activity and Body Image Satisfaction Among University Students: A Cross-sectional Study	Lau Hong Jie		

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.

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

APPENDIX B

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.

Consent:

6. By submitting or providing your personal data to UTAR, you had consented and agreed for your personal data to be used in accordance with 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 kwanqi0220@1utar.my.

Acknowledgement 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 C

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 Study
Tibial Torsion and Leg Length Discrepancy in Idiopathic Scoliosis Among UTAR Students

Student Investigator: Khoo Wan Qi
Department: Department of Physiotherapy
Year and Semester: Y3S1
Supervisor: Puan Nadia Safirah Binti Rusli

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 purposes of this study are to study tibial torsion and leg length discrepancy in idiopathic scoliosis among UTAR students.

Approximately 417 UTAR undergraduate students will participate in this study.

Procedures
If you agree to be in this study, you will be asked fill in the demographic data.

Length of Participation
You will need 2-3 minutes to complete the questionnaire.

Risks and Benefits

There are no risks or benefits from being in this study.

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 010-2367763 or kwanqi0220@1utar.my.

The supervisor can be contacted at safirah@utar.edu.my, concerns, or complaints about the research and wish to talk to someone other than individuals on the research team or

Please keep this information sheet for your records.

APPENDIX D

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 Study
Tibial Torsion and Leg Length Discrepancy in Idiopathic Scoliosis Among UTAR Students

Student Investigator: Khoo Wan Qi
Department: Department of Physiotherapy
Year and Semester: Y3S1
Supervisor: Puan Nadia Safirah Binti Rusli

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 E

Krejcie and Morgan Table to Determine Sample Size for A Given Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

N=Population size

S=Sample size

APPENDIX F

ASSESSMENT FORM

Personal Details:

Name (optional)		
Student ID		
E-mail Address (UTAR)		
Gender	Male	Female
Age		
Weight (kg)		
Height (cm)		
Have you had any surgery done before?	Yes	No
Have you been diagnosed with any type of scoliosis by a doctor before? (Neurological, Congenital, Development, Miscellaneous)	Yes	No
Presence of exhibition of structurally derived curvature and any secondary causes are present	Yes	No

Thigh Foot Angle (TFA)

	1st trial	2nd trial	3rd trial	Average
Right				
Left				

Notes:

Leg Length Discrepancy (LLD)

	1st trial		2nd trial		3rd trial		Average	
	True	Apparent	True	Apparent	True	Apparent	True	Apparent
Right								
Left								

Notes:

APPENDIX G

TURNITIN REPORT

Khoo Wan Qi_20UMB06268_Turnitin Report

by Khoo Wan Qi

Submission date: 23-Dec-2022 10:42PM (UTC+0800)
Submission ID: 1986195770
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