CHONG YI XIAN
ASSOCIATION BETWEEN GASTROCNEMIUS TIGHTNESS, HALLUX VALGUS AND PHYSICAL ACTIVITY AMONG UNIVERSITY STUDENTS: A CROSS-SECTIONAL STUDY
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By

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ASSOCIATION BETWEEN GASTROCNEMIUS TIGHTNESS, HALLUX VALGUS AND PHYSICAL ACTIVITY AMONG UNIVERSITY STUDENTS

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ABSTRACT

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Background:

Hallux valgus (HV) and gastrocnemius tightness (GT) are common musculoskeletal conditions that can affect mobility and physical activity levels. It's important to understand how hallux valgus and GT affect mobility, especially in younger populations. However, there is a lack of studies examining the association between GT, hallux valgus, and physical activity among students.

Objectives:

The aim of this study is to find out the prevalence of Gastrocnemius tightness and Hallux Valgus Deformity and examine the association between Gastrocnemius tightness, hallux valgus deformity, and physical activity among UTAR students.

Method:

A cross-sectional study was conducted with 212 university students aged 18–25 years. HV was assessed using the Hallux Valgus Angle (HVA) via non-radiographic imaging, while GT was evaluated using the Silfverskiold test. Physical activity levels were measured using the International Physical Activity Questionnaire (IPAQ). Data will then be collected and analysed using SPSS version 26. Descriptive statistics will be used to describe the demographic data, while Pearson Chi-square will be used to identify the association between the severity of Hallux Valgus (HV), Gastrocnemius Tightness (GT) and Physical Activity (PA) level.

Results:

The prevalence of HV was 51.9% for mild to moderate deformity, with a mean HVA of 15.78° on both sides. GT was highly prevalent, affecting 84.4% and 83.0% of participants on the left and right sides, respectively. No significant association was observed between HV and physical activity, and GT and physical activity ($p > 0.05$). However, GT was significantly associated with lower physical activity levels on the left side ($p = 0.021$).

Conclusion:

While HV and GT were highly prevalent among university students, only GT showed a significant negative association with physical activity levels. These findings underscore the importance of early detection and targeted interventions to mitigate mobility restrictions and promote active lifestyles among young adults.

Keywords:

Hallux Valgus, Gastrocnemius Muscle Tightness, Physical Activity

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APPROVAL SHEET

This Research project entitled "**ASSOCIATION BETWEEN GASTROCNEMIUS TIGHTNESS, HALLUX VALGUS AND PHYSICAL ACTIVITY AMONG UNIVERSITY STUDENTS**" was prepared by **CHONG YI XIAN** 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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Date: 20/12/2024

PERMISSION SHEET

It is hereby certified that **CHONG YI XIAN** (ID No: **22UMB06584**) has completed this Research project entitled "ASSOCIATION BETWEEN GASTROCNEMIUS TIGHTNESS, HALLUX VALGUS AND PHYSICAL ACTIVITY AMONG UNIVERSITY STUDENTS" under the supervision of **Mr. Siti Hazirah Binti Samsuri** (Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health sciences.

Yours truly,

Xian

(CHONG YI XIAN)

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: CHONG YI XIAN

Date: 20/12/2024

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Abbreviations

UTAR	University Tunku Abdul Rahman
BMI	Body Mass Index
HV	Hallux Valgus
HVA	Hallux Valgus Angle
GT	Gastrocnemius Tightness
PA	Physical Activity
QoL	Quality of Life
IPAQ	International Physical Activity Questionnaire
WHO	World Health Organization
MTP	Metatarsophalangeal
ADF	Ankle Dorsiflexion
MET	Metabolic Equivalent of Task
M	Mean
SD	Standard Deviation
P	p value (Significance)

CHAPTER 1

1.0 INTRODUCTION

1.1 CHAPTER OVERVIEW

The first chapter provides an overview of the study's background and context, which is followed by a discussion of the current study's importance and relevance, its goals, its hypotheses, and an operational definition of terminology.

1.2 BACKGROUND OF THE STUDY

1.2.1 Hallux Valgus

Hallux valgus (bunion) is regarded as one of the most prevalent foot deformities among humans. There are two joints that comprise the big toe. The largest of the joint is the metatarsophalangeal joint (MTP), which is formed by the union of the phalanx, the first toe bone, and the metatarsal, the first long bone of the foot (Nix et al., 2010). Hallux valgus is characterized by a lateral displacement of the big toe at the MTP joint (Mortka & Lisiński, 2015).

Pathomorphological features of the hallux valgus deformity include subluxation of the sesamoids and lateral deviation of the big toe (Schuh et al., 2009). The pathophysiology of hallux valgus (HV) involves an imbalance between the extrinsic and intrinsic foot muscles and the ligaments. The hallux angle increases as a result of the first metatarsal moving medially-dorsally due to increased pressure at its head (Glasoe et al., 2010). Often, hallux valgus can frequently cause extreme pain if left untreated because the big toe bears a large portion of the body's weight while walking. According to some study findings, the pain from hallux valgus deformity might affect activities of daily living and social interaction with others. (Lazarides et al., 2005;Abhishek et al., 2010).

Numerous studies have validated the complex causes of hallux valgus, which encompass several extrinsic and intrinsic factors that predispose individuals to this condition (Mortka & Lisiński, 2015). One research stated that muscle weakness and imbalance of abductor and adductor muscles on big toe may be one of the causes of hallux valgus deformity (Arinci İncel et al., 2003). Moreover, the way we walk, our inherited foot type, or the shoes we wear are usually the causes of the symptoms associated with faulty big toe development. Congenital abnormalities short first metatarsal, joint hypermobility, arthritis, and foot injuries are some additional causes of hallux valgus. Individuals with low arches or flat feet are also more likely to experience these issues (Coughlin & Jones, 2007). Numerous studies have examined various treatments for hallux valgus deformity (Mortka & Lisiński, 2015).

1.2.2 Gastrocnemius Tightness

According to Baumbach et al. (2016), gastrocnemius tightness (GT) is defined as an increase in passive ankle dorsiflexion (ADF) in a flexed knee relative to an extended knee. The posterior insertion of the gastrocnemius (medial and lateral heads) and soleus muscles on the calcaneus act through the Achilles tendon (AT). While the soleus muscle exclusively functions as a plantar flexor, the gastrocnemius muscle aids with plantar flexion at the ankle joint and flexion at the knee joint, such as elevating the heel off the ground. Being a strong muscle in the body, gastrocnemius muscle enables people to propel forward when they run, jump, and stroll (Pascual Huerta, 2014).

Passive tension can be caused by tightness in the soleus or gastrocnemius muscles, or by increased dorsiflexion of the foot. The tensional force, either active or passive, in the Achilles tendon creates a plantarflexion moment at the ankle joint. When bearing weight, a plantarflexion moment at the ankle joint can accelerate the ankle's plantarflexion movement during the propulsive phase of the gait cycle and stabilize the ankle joint over dorsiflexion moments. This helps balance the foot in the sagittal plane (Pascual Huerta, 2014).

The Silfverskiöld test, a clinical examination, is used to diagnose GT. The maximum passive ADF is determined in this test with the knee flexed to 90 degrees and stretched to 0 degrees (P. Barouk & Barouk, 2014). To diagnose GT, a differential of more than 13 degrees is considered as GT.

It is now well known that numerous foot and ankle problems have been linked to GT. Pain in the forefoot, midfoot, and hindfoot are among the symptoms. Even numbness, dull aches, or disruptions may be reported by certain patients, either with or without movement (Ramalingam et al., 2023). Furthermore, it has been demonstrated that GT is linked to a number of musculoskeletal conditions, including metatarsalgia, plantar fasciitis, Achilles tendinopathy, hallux valgus, knee discomfort, and back pain (Malhotra et al., 2018; Chan et al., 2019). The rise in sedentary lifestyles may have resulted in a decrease in physical activity, which in turn may have caused the gastrocnemius muscle to become tight, causing the signs and symptoms that mentioned above. If left untreated, these symptoms could eventually increase even though they are not quite severe or bothersome enough to prompt the patient to seek medical attention (Ramalingam et al., 2023).

1.2.3 Physical Activity

Physical activity is defined by the World Health Organization (WHO) as any bodily movement driven by skeletal muscle that involves the use of energy, such as activities performed during leisure time, transportation, work, or household chores. Exercises of both a moderate and vigorous level are good for health. Walking, cycling, athletics, and physical play are popular activities chosen by the public. Frequent exercise improves fitness, mental health, and lowers the risk of disease in children, adolescents, adults, older individuals, and pregnant women. Sedentary lifestyles, which includes low-energy tasks like sitting, raise the risk of noncommunicable diseases (NCDs) and other poor health outcomes, including as cancer, heart disease, and obesity. (World Health Organization, 2024)

According to global monitoring, 31% of individuals do not engage in physical activity, and by 2030, the percentage is expected to rise to 35%. It is more common for women and elderly persons to be inactive. According to WHO global standards, different age groups and communities should engage in different quantities of physical activity, with the emphasis being on the idea that any physical activity is better than none (Strain et al., 2024; Guthold et al., 2020). Thence, it is important to determine the effects of Gastrocnemius tightness and hallux valgus deformity on physical activities of university students as both may cause discomfort and movement limitation on lower limb.

1.2.4 Importance of Relevance of Study

Understanding the relationship between gastrocnemius tightness, hallux valgus, and physical activity levels among university students—a demographic that is more susceptible to physical inactivity because of academic pressures and sedentary behaviors—makes this study extremely pertinent. Understanding the impact of musculoskeletal disorders, such as hallux valgus and gastrocnemius tightness, on physical activity can be vital in identifying the obstacles to mobility that young adults face. Maintaining health and avoiding the early onset of chronic illnesses need physical activity, yet regular exercise can be discouraged by discomfort or mobility issues.

By knowing how these prevalent musculoskeletal problems relate to levels of physical activity, targeted preventive and rehabilitative interventions can be developed to encourage an active lifestyle in this population. In addition to advancing our understanding of how particular biomechanical problems affect activity, this study emphasizes the importance of early interventions in student populations in order to promote long-term musculoskeletal health and avoid the possible worsening of these conditions.

1.3 RESEARCH QUESTIONS

1. What is the prevalence of Gastrocnemius tightness and hallux valgus deformity among UTAR students?
2. What is the association between Gastrocnemius tightness, hallux valgus deformity, and physical activity among UTAR students?

1.4 PROBLEM STATEMENTS

The study aims to investigate the potential association between Gastrocnemius tightness, hallux valgus deformity and physical activity among university students. According to some study findings, the uncomfortable symptoms from hallux valgus deformity and Gastrocnemius tightness might affect activities of daily living and social interaction with others. (Lazarides et al., 2005;Abhishek et al., 2010; Ramalingam et al., 2023). If left untreated, these symptoms could eventually increase even though they are not quite severe or bothersome enough to prompt the patient to seek medical attention (Ramalingam et al., 2023). The theory that a person's level of physical activity is impacted by tight Gastrocnemius and Hallu Valgus deformity, however, are not as well supported by research. There is a notable gap in understanding how Gastrocnemius tightness and hallux valgus interact, and how these conditions affect their physical activity. In order to promote better foot health and improve physical activity, this topic is crucial as hallux valgus deformity and Gastrocnemius tightness can significantly affect mobility, athletic performance, and overall quality of life (Lazarides et al., 2005;Abhishek et al., 2010). By addressing the gap, the research seeks to contribute valuable insights to the field, potentially informing preventative and therapeutic strategies to enhance the well-being and performance of young adults.

1.5 RESEARCH OBJECTIVES

1. To determine the prevalence of Gastrocnemius tightness and hallux valgus deformity separately among UTAR students.
2. To determine the association between Gastrocnemius tightness and hallux valgus deformity among UTAR students.
3. To determine the association between Gastrocnemius tightness and physical activity among UTAR students.

4. To determine the association between hallux valgus deformity and physical activity among UTAR students.

1.6 HYPOTHESIS

Null Hypothesis (H_0)

1. There is no significant association between Gastrocnemius tightness and hallux valgus deformity among UTAR students.
2. There is no significant association between Gastrocnemius tightness and physical activity among UTAR students.
3. There is no significant association between hallux valgus deformity and physical activity among UTAR students.
4. There is no significant association between Gastrocnemius tightness, hallux valgus and physical activity among UTAR students

Alternate Hypothesis (H_A)

1. There is a significant association between Gastrocnemius tightness and hallux valgus deformity among UTAR students.
2. There is a significant association between Gastrocnemius tightness and physical activity among UTAR students.
3. There is a significant association between hallux valgus deformity and physical activity among UTAR students.

4. There is an association between Gastrocnemius tightness, hallux valgus and physical activity among UTAR students

1.7 OPERATIONAL DEFINITION

1. Hallux valgus

Hallux valgus is a foot condition characterized by the deviation of the big toe towards the smaller toes, resulting in a visible prominence on the side of the foot (Cho et al., 2009). Hallux valgus is measured by Hallux valgus Angle (HVA). It is measured with the angle formed by the proximal phalanx's longitudinal axis and the first metatarsal's longitudinal axis (Lee et al., 2012). HVA greater than 15 degrees typically indicates the presence of hallux valgus (Cho et al., 2009).

2. Gastrocnemius tightness

Gastrocnemius tightness refers to the reduced flexibility or limited range of motion at the ankle, which is the thick band of tissue connecting the calf muscles to the heel bone. (Kirsten Nunez, 2019). The measurement of Gastrocnemius tightness, which is Silfverskiold test, has been proven to be effective. It is based on passive examination of the foot, which is ankle dorsiflexion when knee is flexed and extended (Goss et al., 2020).

3. Physical activity

Physical activity is the movement of the body caused by skeletal muscles that requires the use of energy. Any movement, whether it be for recreation, transportation to and from locations, or employment, is considered physical activity (World Health Organization, 2022). The questionnaire used for physical activity assessment is International Physical Activity Questionnaire (IPAQ). It has two versions which are long form and short form IPAQ. The 27-item long form IPAQ is a self-reported physical activity assessment tool designed for use with individual adult ages 18 to 69 (Craig et al., 2003).

1.8 STRUCTURE OF RESEARCH PROJECT

The research paper is organized as follows: Chapter 1 introduces the background of the study, encompassing the research questions, objectives, and the importance and relevance of the topic. Chapter 2 provides a literature review, summarizing key insights from previous studies on related subjects. Chapter 3 outlines the research methodology, detailing the research design, sampling strategy, instruments used, data collection procedures, and data analysis methods. Chapter 4 presents the results of the study, including descriptive and inferential analyses, as well as hypothesis testing. Finally, Chapter 5 reviews the study's findings, discusses its limitations, and offers recommendations for future research.

Chapter 2

2.0 REVIEW OF LITERATURE

2.1 CHAPTER OVERVIEW

This chapter reviews existing journals and literature on a range of topics, providing a foundation for this research project.

2.2 PREVALENCE OF HALLUX VALGUS

One of the common foot deformities in medical practice is hallux valgus, which is frequently accompanied by severe functional impairment and foot pain (Nix et al., 2010). Numerous research has been conducted to determine the prevalence of hallux valgus in people from all backgrounds.

Hallux valgus (HV) is a common foot deformity with varying prevalence rates reported across different populations. A study by Nix et al. (2010) investigated the general population and found that 58.7% of people had a hallux valgus deformity, with prevalence rates of 23% in those over 18 and 35.7% in individuals over 65. Similarly, Menz et al. (2023) found that the incidence of HV in adults aged 50 and older was 20.1%, with a baseline prevalence of 30.4%. Over a 7-year period, 33.6% of participants experienced progression of the deformity, highlighting its significance in older populations.

A systematic review conducted by Cai et al. (2023). identified a global pooled prevalence of 19% for HV, with higher rates in females (23.74%) compared to males (11.43%). The review also revealed regional differences, with prevalence rates of 21.96% in Asia, 29.26% in Oceania, and 22.7% in individuals aged 60 and older.

In specific regional studies, Hamam et al. (2023) reported an HV prevalence of 37.2% among participants in Saudi Arabia, with 7.9% presenting unilateral HV and 29.3% bilateral HV, which was predominantly mild (Hamam et al., 2023). Another study in Riyadh, Saudi Arabia, by Alkhaibary et al. (2019), found an overall prevalence of 43%, with rates of 30.7% in males and 49.2% in females (Alkhaibary et al., 2019). Similarly, Shraddha and Aishwarya (2024) observed a prevalence of 34% among females in South Pune, with 10% of those affected experiencing big toe pain, indicating its impact on the population (Shraddha & Aishwarya, 2024).

Gender and age are notable factors influencing the prevalence of HV. Mazhar found that 75.46% of female school teachers exhibited HV, with higher rates among older females (43.96%) compared to younger females (31.5%) (Mazhar, 2024). Additionally, an observational cross-sectional study by Ekwere et al. (2016) assessed the prevalence of HV among 200 medical students aged 18–30 in Nigeria, with male and female participants equally divided.

Studies have also explored the relationship between HV and associated symptoms. Cho et al. (2009) conducted a cross-sectional study in a rural Korean community involving 364 participants. The study reported that 48 participants had moderate to severe HV, defined by an angle exceeding 25 degrees. This severity was significantly associated with pain, reduced foot function, and worsening foot health. Painful HV was more prevalent among females ($p = 0.022$), those with a lower education level ($p = 0.003$), and those with knee pain ($p = 0.003$) (Cho et al., 2009).

Finally, HV prevalence in normal individuals was examined in a study which reported rates of 38.59% in males and 31.46% in females for the right foot, and 45.61% in males and 39.15% in females for the left foot (Hotwani, 2021).

To sum up, females are more likely to have hallux valgus, and the prevalence of hallux valgus among female and male rises with age. These findings highlight the condition's widespread occurrence and variability based on gender and laterality.

2.3 RISK FACTORS OF HALLUX VALGUS

The development or progression of hallux valgus deformity is thought to be influenced by several factors, including muscle weakness and imbalance between the big toe's abductor and adductor muscles. The big toe moves away from the other toes with the help of the abductor muscles and toward them with the adductor muscles. The alignment and stability of the big toe joint may be impacted by an imbalance between these muscle groups (Arinci İncel et al., 2003). It is believed that there are also some contributing factors that can lead to the development of hallux valgus such as wearing inappropriate footwear, gender, structural issues, biomechanical factors, and family history, have been linked to the condition. (Colin, 2022).

Hallux valgus is more frequently caused by genetic factors, particularly in cases of adolescent hallux valgus (OrthoInfo, 2022). Given that 58–90% of HV patients report a family history of this condition, there may be a genetic component to the condition (Piqué-Vidal et al., 2007). Piqué-Vidal et al. report that 56% of probands' pedigrees showed a hallux valgus penetrance. When it came to the gender of parents who have hallux valgus, the affected family branch, and the gender of relatives who have a hallux valgus deformity, the female dominated. Ninety percent of probands had a family history of bunion deformity (Piqué-Vidal et al., 2007).

Footwear is regarded as one of the more significant environmental risks, especially for women. This is founded on the observation that the prevalence of hallux valgus is higher in populations with shoes than in those without (Munteanu et al., 2017). In a cross-sectional study, footwear with an elevated heel or that are ill-fitting (too narrow or constrictive toe-box) have been linked to hallux valgus (Al-Abdulwahab & Al-Dosry, 2000).

Moreover, BMI will be one of the risk factors of hallux valgus deformity. Hallux valgus was linked to lower BMI in women aged 20 to 64, but higher BMI was linked to associations in men. The findings of this study by Nguyen et al. (2010) imply that men and women may have different etiologic mechanisms for hallux valgus (Nguyen et al., 2010). who investigated the relationship between elderly hallux valgus and various characteristics, including foot pain (Dufour et al., 2014).

2.4 DIAGNOSIS FOR HALLUX VALGUS DEFORMITY

Radiographical Measurement

The main imaging modality used to evaluate HV is typically plain radiography. X-rays are frequently utilized to view the foot's bone structure. By measuring angles and detecting any bone abnormalities, this technique aids in determining the severity of HV (Hurn, 2023). The most accurate and repeatable method of diagnosing hallux valgus is thought to be using radiographs to determine bone alignment. This might therefore be regarded as a "gold standard" (Janssen et al., 2014).

It has been demonstrated that measurements from standardized static weight-bearing foot radiographs are a valid and objective method of evaluating the dimensions of soft tissues as well as bony structure (Janssen et al., 2014;Roddy et al., 2007). A platform with a central beam was used to acquire weight-bearing dorsoplantar radiographs while the participant was standing normally (Janssen et al., 2014).

HV deformity can be measured using different radiological angles on weight-bearing anteroposterior (AP), oblique, lateral, and sesamoid axial views of the foot. The Hallux Valgus Angle (HVA), First Metatarsophalangeal Angle (IMA), and Distal Metatarsal Articular Angle (DMAA), which are commonly used radiological measurements, all involve calculating the angles between the first ray or adjacent foot articulations. But there might be differences or irregularities in the measurements made by various people evaluating the same radiographs, as well as in the outcomes made by the same person during several assessments (Lee et al., 2012;Ray et al., 2019).

Furthermore, it has been demonstrated that the Linear Hallux Valgus Offset (LHVO) is a more precise and easier method for determining the severity of hallux valgus deformity. The calculation method is first drawing a straight vertical line from the distal phalanx tip to the lateral edge of the first metatarsal base (1st line). Next draw a line from the 1st line to the lateral edge of the first metatarsal's metatarsophalangeal joint, another 90-degree horizontal line is drawn (2nd line). The 1st line and 2nd line's measured distance from one another are LHVO. Measuring the first ray metatarsal head width and correlated it with LHVO to create an LHVO Index in order to investigate the clinical significance of LHVO further. The broadest portion of the first ray metatarsal head was used to measure its width. To calculate the LHVO Index, the corresponding LHVO was divided by this measurement. LHVO index measurement could use to determine whether a distal metatarsal osteotomy would correct the HV deformity (Saad et al., 2022).

Clinical and Physical Examination

Diagnosing hallux valgus traditionally involves a comprehensive physical assessment by a healthcare professional. The clinician evaluates the foot's alignment, observes the position of the great toe, assesses its range of motion, and considers any associated symptoms (Hurn, 2023). The examination is performed with the patient in both seated and standing positions to provide a complete understanding of the deformity (Ray et al., 2019).

During the assessment, the clinician identifies specific areas of pain through patient history and palpation, as pain at the medial eminence is a common symptom in hallux valgus. Patients may also report generalized pain in the first metatarsophalangeal (MTP) joint, discomfort from lesser toe deformities, or pain at the lesser metatarsal heads caused by transfer metatarsalgia (Ray et al., 2019). The first MTP joint is also carefully examined for signs of pain, crepitus, skin changes, or restricted motion, which may indicate arthritic changes. Additionally, the clinician checks for other related conditions, such as hammertoe deformity, pes planus, Achilles tendon tightness (equinus), or first ray hypermobility (Ray et al., 2019).This detailed approach ensures a thorough understanding of the patient's condition and guides appropriate management.

Clinical goniometry is a widely used method to assess the degree of valgus deviation in hallux valgus. This approach involves using a 360-degree clear plastic universal goniometer with a locking device, such as the Quint 7″ True Angle (Quint Measuring Systems, San Ramon, USA), to measure the Hallux Valgus Angle (HVA). Measurements are performed while the barefoot participant stands in a normal weight-bearing position. The goniometer's center of rotation is positioned over the first metatarsophalangeal (MTP) joint space on the medial contour of the foot. One arm of the goniometer is aligned parallel to the medial contour of the first metatarsal, and the other is aligned parallel to the medial contour of the proximal phalanx of the hallux, following the guidelines of the American Academy of Orthopaedic Surgeons. The scale is accurate to one degree, and a mean value is calculated from three measurements to ensure reliability (Kilmartin & O'Kane, 2010;Janssen et al., 2014).

Additionally, valgus deviation can be assessed through pressure profile footprints obtained using various tools, such as the Harris and Beath (ink) foot printing mat, Podotrack (a carbon-paper-based footprint mat for pressure gradients), or electronic systems for computerized plantar pressure measurements, further supporting clinical evaluation (Urry & Wearing, 2001;Janssen et al., 2014).

3D Scanning Technology

A study conducted by Hurn in 2023 presents a new method based on 3D scanning technology for mobile phones. With this approach, foot scans are analyzed using a computer vision algorithm to determine a surrogate angle that represents the severity of HV. Its accuracy was assessed by comparing it to traditional techniques. An evaluation of HV that is easier to use and more accessible is made possible by this novel method. With an Area Under the Curve (AUC) score of 0.947, it has demonstrated great accuracy and may be conducted remotely, which is advantageous for patients in underserved areas (Hurn, 2023).

In addition, the Neatsy App, a smartphone app that creates a 3D scan of a patient's foot using a structured light camera system. The foot's shape is represented in three dimensions by a point cloud, which is a collection of points created by this scan. The Iterative Closest Point (ICP) algorithm is used by the app to combine several photos into a single, cohesive model (Ghandour et al., 2024).

2.5 ANKLE DORSIFLEXION (ADF)

Various lower extremity pathologies, such as plantar heel pain, metatarsalgia, foot stress fractures, and Achilles tendinopathy, are associated with limited ankle dorsiflexion (ADF) (Bolívar et al., 2013;Patel & DiGiovanni, 2011; Baumbach et al., 2014). Reduced ADF during gait increases forefoot pressure, which may contribute to the development of these conditions. Research has shown that improving ADF in affected patients can alleviate these symptoms (Chimera et al., 2012). ADF limitations may result from osseous, ligamentous, neurological, or muscular restrictions, with musculus gastrocnemius tightness (MGT) being the most common cause (Patel & DiGiovanni, 2011).

The gastrocnemius muscle affects ADF because it spans both the knee and ankle joints. Under normal conditions, the muscle is under maximum tension when the knee is extended, as this position maximizes the distance between its origin and insertion, thereby restricting ADF. Conversely, flexing the knee reduces gastrocnemius tension by bringing the origin and insertion closer together, allowing greater ADF. At this point, other structures within the ankle joint limit further dorsiflexion (Baumbach et al., 2014).

In symptomatic patients, initial assessment should measure ADF with the knee fully extended. If ADF improves with knee flexion, the restriction is likely due to MGT. Patients with MGT typically display reduced ADF when the knee is extended but demonstrate increased ADF with knee flexion (DiGiovanni et al., 2002; Baumbach et al., 2014). Identifying isolated MGT is critical for physiotherapists and physicians, as it can be addressed through stretching exercises or endoscopic gastrocnemius recession. However, if knee flexion does not improve ADF, the limitation is not caused by the gastrocnemius (Baumbach et al., 2014).

2.6 MEASUREMENT OF ANKLE DORSIFLEXION (ADF)

Many tests are described in the literature to evaluate ADF. These tests fall into one of three categories: instrumented, weightbearing, or non-weightbearing (Munteanu et al., 2009;Krause et al., 2011). Non-weightbearing measures are most frequently taken in daily practice. Additionally, there is a considerable difference in the maximum ADF between weightbearing and non-weightbearing individuals (Alon Rabin & Zvi Kozol, 2012). There is no established norm for the amount of knee flexion required to remove the musculus gastrocnemius's influence on ADF, regardless of the test used. According to Bolívar et al. (2013), the majority of studies that used non-weightbearing measures used a knee flexion of 90°.

ADF is measured clinically using a variety of techniques. Common techniques include taking non-weightbearing measurements in weight-bearing positions like the modified lunge and at different degrees of knee flexion using an inclinometer or universal goniometer (Vicenzino et al., 2006). The impact of the gastrocnemius, which crosses both the knee and ankle joint, is probably reflected in variations in measures brought on by knee position. According to DiGiovanni et al., (2002), ADF measures obtained with the knee flexed 90 degrees are therefore higher than those obtained with the knee extended. More ADF is produced by the weight-bearing modified-lunge approach than by any of the other positions (Malliaras et al., 2006).

The responsiveness and reliability of using goniometers and inclinometers in clinical settings to measure ADF have been assessed. While responsiveness is a measurement's capacity to identify change that isn't the result of measurement mistake, reliability is the degree of consistency. Using a typical goniometer to quantify ADF, researchers report poor to moderate interrater reliability and moderate to high intrarater reliability. When measuring ADF in a modified-lunge position with an inclinometer, high interrater and intrarater reliability have been documented (Krause et al., 2011).

2.7 PREVALENCE OF GASTROCNEMIUS TIGHTNESS

One of the most prevalent tight muscles in the lower extremities, which is the gastrocnemius muscle, are distinguished by the crossing of the ankle and knee joints. The range of motion in the ankle dorsiflexion and knee extension can be decreased by a lack of flexibility in the gastrocnemius muscle. (Hertling and Kessler, 2006; Kisner and Colby, 2007; You et al., 2009) When the Gastrocnemius tendon is stiff and inflexible, it is referred to as Gastrocnemius tightness. This may result in Achilles tendinopathy and make it difficult to perform ankle movements such as plantar flexion and dorsiflexion. This is becoming more common in the general population, with 18 cases per 100,000 persons annually (Sobhy et al., 2018).

The prevalence and incidence of gastrocnemius tightness vary across populations and settings. Research indicates a notable occurrence of this condition, particularly among specific groups like individuals with asymptomatic flat feet and dancers. A study involving 175 individuals with asymptomatic flat feet reported that 76.6% experienced gastrocnemius tightness, while 15.42% experienced soleus tightness (Mohamed et al., 2022). The same study also revealed a higher prevalence of calf muscle tightness among females. Additionally, among dancers, 52% were found to have myofascial trigger points in the gastrocnemius muscle, reflecting the significant strain their activities place on these muscles (Guruprasad et al., 2019).

In another study conducted on clinic staff in Kedah, Malaysia, researchers explored the incidence of gastrocnemius tightness in a clinical population, emphasizing its importance, though specific incidence rates were not cleared (Ramalingam et al., 2023).

Gastrocnemius tightness is commonly observed in patients with foot and ankle pathologies, with prevalence rates reaching as high as 96.5% in such conditions (Hill, 1995). Research highlights that a significant number of individuals with foot and ankle pathology (FAP) exhibit isolated gastrocnemius tightness, particularly those with forefoot pathology (FoP). Among the FAP patients, 21.6% (21 individuals) demonstrated abnormal levels of gastrocnemius tightness, defined as greater than 13 degrees, which exceeds the normal range. Specifically, 37.5% of patients in the FoP subgroup showed abnormal tightness, compared to only 13.8% in the non-forefoot pathology (NFoP) subgroup (Malhotra et al., 2018).

A study conducted by Riemann et al. (2001) found that healthy men between the ages of 18 and 30 had more ankle tightness in dorsiflexion compared to women of a similar age. They concluded that male patients need higher intensity and longer stretching durations to achieve comparable increases in ankle dorsiflexion when compared with female. Furthermore, it has been proposed in the past that changed tendon tightness in the age-related reduction in muscular function during functional tasks. Besides, certain studies found that older people had less stiff Achilles tendon than the younger ones (Karamanidis & Arampatzis, 2005).

Additionally, according to some research, older people's postural balance is influenced by decreasing Achilles tendon tightness (Onambélé et al., 2007). To sum up, there is lack of evidence supporting the prevalence of Gastrocnemius tightness among younger generation especially those studying in university.

2.8 RISK FACTORS OF GASTROCNEMIUS TIGHTNESS AND ITS ACCOMPANYING EFFECTS

Systemic disease, repeating minor muscle strains over time, poor posture, and neuromusculoskeletal lesions are some of the pathogenic conditions that can result in muscular tightness (Zito et al., 2006). According to Ramalingam et al. (2023), tightness of the Gastrocnemius can cause pain in the forefoot, midfoot, and hindfoot. Even numbness, dull aches, or irregularities may be reported by certain patients, either with or without movement. It's also possible that a decrease in physical activity brought on by the rise in sedentary lifestyles has exacerbated the tightness in the gastrocnemius muscle (Ramalingam et al., 2023).

Wu et al. (2020) claims that tightness in the gastrocnemius muscles impacts hip and pelvic movement during walking, affecting physical fitness and possibly increasing the risk of overuse injuries because of the decreased ability to extend the muscle. It has been suggested that nocturnal calf cramps may be caused by tightness in the gastrocnemius muscle (Wu et al, 2020).

According to Radford et al. (2006), several lower limb conditions, such as plantar fasciitis and Achilles tendinitis, are associated with tightness in the lower leg muscles and a decreased range of ankle joint dorsiflexion. Several research have found a connection between tightness in the gastrocnemius muscle with plantar fasciitis, hallux valgus, tension in the Achilles tendon when weight bearing, and pronation of the foot. In a study involving 223 individuals, Nakale et al. (2018) also discovered a connection between osteoarthritis, hallux valgus, and plantar fasciitis.

2.9 RESEARCH GAP

While it has been suggested that gastrocnemius tightness (GT) is one of the most common causes of restriction in ankle dorsiflexion, no substantial research has been done to ascertain the incidence of GT in the younger population (Pascual Huerta, 2014). According to a recent study, the plantar aponeurosis, the Achilles tendon, the calcaneus, the plantar aponeurosis, and the plantar plate inserting into the base of the proximal phalanx of great toe are the anatomical and biomechanical relationships between the gastrocnemius and hallux valgus (L. S. Barouk, 2014). Plantar aponeurosis is made up of the medial section of the central band, which extends distally and obliquely before integrating into the base of the proximal phalanx of the great toe. Hence, they surmised that tightness of the gastrocnemius augments the windlass mechanism by tensioning the plantar aponeurosis, which also leads to an increase in valgus deforming forces at the MTPJ (O' Reilly et al., 2021). However, the theory that gastrocnemius tightness contributes to the development of hallux valgus is currently not well supported by data or evidence. The purpose of this research is to find out the incidence rates of GT and Hallux Valgus separately among university students and to look for the associations between these conditions and physical activity among students.

CHAPTER 3

3.0 METHODS

3.1 CHAPTER OVERVIEW

This chapter outlines the research methodology employed in the study, encompassing the research design, ethical approval, sampling strategy, research instruments, study procedures, and data analysis strategies.

3.2 RESEARCH DESIGN

The study design for this study is observational cross-sectional study. In a cross-sectional study, the researcher simultaneously assesses the study participants' exposures and outcomes. For population-based surveys and determining the frequency of diseases in clinic-based samples, cross-sectional designs are used. These studies are typically less expensive and can be completed more quickly (Setia, 2016). Recruitment took place in the KA and KB Block of UTAR Sungai Long Campus.

3.3 RESEARCH SETTING AND DURATION

The study was carried out in UTAR KA block Classroom 200A, spanning a total duration of seven weeks. It took place from October 28, 2024, to December 13, 2024, with five weeks allocated for data collection. Participants were primarily recruited through face-to-face interactions and social media platforms, such as Facebook, WhatsApp and Instagram.

3.4 PARTICIPANTS' CHARACTERISTICS

The target population for this study comprised undergraduate students at UTAR, Sungai Long. A total of 278 participants were recruited, regardless of gender, based on inclusion and exclusion criteria listed below.

The participants were undergraduate students at UTAR Sungai Long, aged 18 to 25. Convenience sampling was employed due to its practicality and cost-effectiveness, with participants selected from the accessible population.

Participants were eligible for inclusion in this study if they fulfilled the following criteria:

1. Both genders
2. Age of 18-25 years old
3. Studying undergraduate programs at UTAR Sungai Long Campus
4. Able to write and read English
5. Voluntary participation

Participants were excluded from this study if they met any of the following criteria:

1. History of previous foot or ankle fracture (Goss et al., 2020).
2. History of surgery or a current medical condition of the great toe (Coughlin & Jones, 2007).
3. History of steroid injections to the heel (Pearce et al., 2021).
4. History of rheumatoid arthritis or other inflammatory diseases (Coughlin & Jones, 2007).
5. Knee pain or knee stiffness

3.5 ETHICAL APPROVAL

All participants were required to read and sign a consent form and provide their demographic information after the study procedures were thoroughly explained to them. The collected data and results were digitized and documented using Microsoft Excel. This study was conducted with prior ethical approval from the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman (refer to Appendix A).

3.6 SAMPLING METHOD

Convenience sampling method is used in this study. It will be used to select the samples because it is more convenient and lower cost. Convenience sampling, sometimes referred to as Haphazard sampling or Accidental sampling, is a nonprobability or nonrandom sampling technique in which study participants who satisfy specific practical requirements—such as ease of access, close proximity, availability at a specific time, or willingness to participate—are included in the sample (Etikan, 2016). It also refers to the population research subjects that the researcher may readily reach (Lisa M. & Kristie, 2008).

3.7 SAMPLE SIZE

The sample size was calculated using the OpenEpi software. The estimated population size of undergraduate students in UTAR Sungai Long Campus aged 18-25 is 1000 (n=1000). Based on the OpenEpi software, the sample size is 278 individuals to reach 95% confidence level.

Sample Size for Frequency in a Population

Population size(for finite population correction factor or fpc)(*N*):	1000
Hypothesized % frequency of outcome factor in the population (*p*):	50%+/-5
Confidence limits as % of 100(absolute +/- %)(*d*):	5%
Design effect (for cluster surveys-*DEFF*):	1

Sample Size(*n*) for Various Confidence Levels

ConfidenceLevel(%)	Sample Size
95%	278
80%	142
90%	214
97%	321
99%	400
99.9%	521
99.99%	603

Equation

Sample size $n = [DEFF*Np(1-p)]/ [(d^2/Z^2_{1-\alpha/2}*(N-1)+p*(1-p)]$

Results from OpenEpi, Version 3, open source calculator--SSPropor
Print from the browser with ctrl-P
or select text to copy and paste to other programs.

Figure 3.1: OpenEpi software Sample Size Calculation

3.8 RESEARCH INSTRUMENT

3.8.1 Hallux valgus angle (HVA)

Hallux valgus angle (HVA) is one of the metrics used to assess the deviation of the big toe (hallux). It is the angle formed by the proximal phalanx's longitudinal axis and the first metatarsal's longitudinal axis (Figure 1) (Yamaguchi et al., 2019).

According to a study, HVA is a reliable method for predicting hallux valgus deformity(Yamaguchi et al., 2019;Cakar et al., 2023). The reason for this is that when compared to other metrics like intermetatarsal angle, interphalangeal angle, sesamoid rotation angle, and first metatarsal protrusion distance, the HVA exhibited the highest intraclass correlation coefficient (ICC) which is 0.985 (Yamaguchi et al., 2019). Besides, even though hallux valgus is a complicated three-dimensional deformity that can only be explained on one plane, the hallux valgus angle was employed as the gold standard and a dependent variable in multiple regression analysis (Lee et al., 2012: Cakar et al., 2023).

According to Cho et al (2019), if the angle in either foot is greater than 15°, it is considered to as hallux valgus deformity (Cho et al., 2009). Furthermore, the degree of hallux valgus deformity as determined by weight-bearing anteroposterior radiographs is used to classify the severity of the deformity, according to the measuring methodology developed by (Ekwere et al., 2016).

i. HVA <30° defines mild deformity

ii. HVA <40° defines moderate deformity

iii. HVA >40° indicates a severe deformity

In this study, the outcome measure is HVA by using non-radiographic measurement. It is determined by the intersection of two lines: one representing the longitudinal axis of the first metatarsal and the other representing the longitudinal axis of the first proximal phalanx (as shown in Figure 1). The longitudinal axis of each bone is defined by connecting the centers of the proximal and distal metaphyseal or diaphyseal regions (Yamaguchi et al., 2019).

The HVA was measured following the protocol described by Yamaguchi et al. (2019), Ekwere et al. (2016), and Cakar et al. (2023), with the steps outlined as follows:

1. Participants stood in a relaxed posture with their feet parallel and spaced shoulder-width apart.
2. The distal bony prominence of the first metatarsal, the centers of the proximal and distal phalanx of the great toe, were palpated, and white stickers were placed on these three landmarks.

3. Photographs of the participants' feet were taken using a smartphone (type unspecified), positioned at a 20-degree angle to the ground.

4. Each photograph was anonymized, saved in JPEG format, and analyzed using an image-analysis application (Angle Meter Detector).

5. The HVA for both feet was calculated and classified into categories: no deformity, mild, moderate, or severe.

Figure 3.2: Hallux valgus angle measurement (Yamaguchi et al., 2019)

3.8.2 **Silfverskiold Test**

The Silfverskiold test was originally described by Nils Silfverskiöl in 1923. It is a method of physical examination designed to assist medical practitioners in determining how tight an ankle can move. Gastrocnemius tightness is suggested if there is greater ankle dorsiflexion with the knee flexed than with the knee extended (Matt, 2023). When the knee is in extension, there is a differential of at least 13 degrees of dorsiflexion when the knee is flexed, and there is tightness in the gastrocnemius when passive ankle dorsiflexion is negative or at neutral (Figure 2). When the knee is extended and the active ankle dorsiflexion is less than 10 degrees, this is considered as a short gastrocnemius (P. Barouk & Barouk, 2014). The measurement techniques are taken as follows, in accordance with the measurement protocol used by Barouk & Barouk (2014), Goss et al. (2020).

1. The subject is asked to remove the shoes and socks and is positioned in supine lying on the physio bed.
2. The lateral malleolus and the fifth metatarsal of both foot are labelled with a sticker as fulcrum point and moving point.
3. Extend the patient's knee, dorsiflex the ankle, and use one hand to lock the midfoot into an anatomical position while the other stabilizes the hindfoot by grabbing and holding the calcaneus.
4. Use a goniometer to measure the dorsiflexion angle. (stationary arm pointing along lateral aspect of fibula bone, moving arm pointing at lateral aspect of fifth metatarsal).

5. Next, bend the knee to 90 degrees, dorsiflex the ankle (grab the foot as same with step 2) and measure the angle using goniometer.
6. Note down the differences in range of ankle dorsiflexion while the knee is extended and flexed.
7. Repeat steps 2 to 5 again on the other leg.
8. The dorsiflexion angle with the knee flexed and extended on both legs will be measured three times on each side, and the average value will be computed.

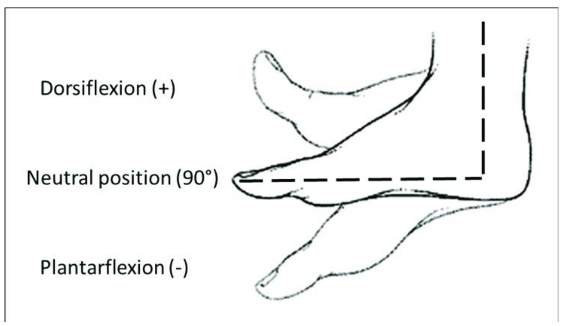

Figure 3.3: Definition of joint angles used in the study (Germanotta et al., 2017).

3.8.3 International Physical Activity Questionnaire (IPAQ)

Students with tight Gastrocnemius and hallux valgus have their physical activity levels evaluated using the International Physical Activity Questionnaire (IPAQ). It evaluates physical activity in a wide range of contexts, such as leisure time, transport-related activities, and work-related activities (Craig et al., 2003). IPAQ is proven as a valid and reliable tool for tracking population levels of physical activity among adults (18–65 years of age). Spearman's correlation coefficients clustered between 0.69 and 0.91, showing high test-retest repeatability. For national monitoring, the short IPAQ form "last 7 d recall" is suggested, whereas the long form is recommended for studies which require a more thorough evaluation (Craig et al., 2003 ; van der Ploeg et al., 2010).

The short form version is used in this study. Walking, moderate-intensity activities, and vigorous-intensity exercises are the specific activities that are evaluated. Besides, frequency (measured in days per week) and duration (minutes per day) are gathered separately for each specific activity type (Sjostrom et al., 2005).

Additionally, activity volume can be measured by assigning energy expenditure values, defined in METs (multiples of the resting metabolic rate), to each activity. This generates a score expressed in MET-minutes, calculated by multiplying the MET value by the duration in minutes. For a person weighing 60 kilograms, MET-minutes are equivalent to kilocalories. Kilocalories for individuals of other weights can be calculated using the formula: MET-minutes × (weight in kilograms / 60) (P. H. Lee et al., 2011).

Average MET values are assigned to each type of activity. For instance, an average MET value is calculated for walking by considering all types of walking. The same approach applies to moderate and vigorous activities. For IPAQ data analysis, the following MET values are used: Walking = 3.3 METs, Moderate-intensity = 4.0 METs, and Vigorous-intensity = 8.0 METs (P. H. Lee et al., 2011).

Physical activity levels on the IPAQ are categorized as high, moderate, or low based on the intensity, duration, and frequency of activities. A high level of physical activity indicates engaging in approximately one hour of at least moderate-intensity activity per day. This can be achieved by performing vigorous-intensity activity on at least three days, totaling at least 1500 met-minutes per week, or by accumulating seven or more days of walking, moderate, or vigorous activities with a combined total of at least 3000 met-minutes per week (Forde, 2012).

A moderate level of physical activity suggests performing activities equivalent to about half an hour of at least moderate-intensity activity on most days. This includes three or more days of vigorous-intensity activity or walking for at least 30 minutes per day, five or more days of moderate-intensity activity or walking for at least 30 minutes per day, or five or more days of any combination of walking, moderate, or vigorous activities totaling at least 600 met-minutes per week (Forde, 2012).

A low level of physical activity indicates that the individual does not meet the criteria for either moderate or high levels of activity (Forde, 2012).

When calculating MET-minutes, all activity durations must first be converted to minutes, as using hours may lead to errors. Activity bouts exceeding 3 hours should be truncated to a maximum of 180 minutes per session, allowing a maximum of 21 hours (or 1260 minutes) of activity per week for any category (3 hours per day for 7 days). To determine MET-minutes per week, multiply the MET value assigned to the activity (Walking = 3.3, Moderate = 4.0, Vigorous = 8.0) by the duration of the activity in minutes and the number of days it was performed. For example, if an individual reports walking for 30 minutes on 5 days a week, the MET-minutes for walking would be calculated as $3.3 \times 30 \times 5 = 495$ MET-minutes per week. Finally, sum the MET-minutes from all activity categories (walking, moderate, and vigorous) to obtain the total weekly MET-minutes of physical activity (Forde, 2012).

3.9 PROCEDURE

Recruitment process

This study is a cross-sectional design which requires 278 participants and is determined by the result of sampling size calculation using OpenEpi Software. Students between the ages of 18 and 25 who have enrolled in undergraduate course at UTAR Sungai Long Campus are targeted for recruitment. Convenience sampling method is used, participants are recruited on UTAR Sungai Campus via face-to-face method, and social media platform (Facebook, Instagram and WhatsApp) as well. Subjects who are recruited will receive a digital questionnaire via Google Form. The purpose of the questionnaire is to gather participants' consent and demographic data, at the same time, select suitable participants through the screening test. Participants will be required to complete both portions of the informed consent form and read through the statements. The questionnaire's contents comprise:

I. Informed consent form (Refer to Appendix B)

II. Demographic data (Refer to Appendix C)

III. Screening Test (Refer to Appendix D)

This demographic data form was used to obtain the individual's name, age, gender, height, weight. It mainly aims to screen the individuals based on the inclusion criteria of this study, requiring the individual to answer questions based on their injury history, medical history and surgical history of lower limb. After that, participants who met the inclusion criteria then filled up the informed consent form to give their consent after reading the information sheet.

Data Collection

Data collection took place in KA block 200A classroom in UTAR over a five-week period. Each participant who visited the KA200A classroom was briefed on the study's purpose and asked for their consent to participate. Eligible participants provided their demographic and relevant information, while those who did not meet the criteria were excluded. Participants who met the inclusion criteria underwent screenings for Hallux Valgus and Gastrocnemius tightness. Their physical activity levels were then assessed using a 7-question questionnaire.

Two outcome measures will be used to assess the severity of hallux valgus deformity and Gastrocnemius tightness which is Hallux valgus angle (HVA) and Silfverskiold test. Besides, the International Physical Activity Questionnaire (Refer to Appendix E) will be used to assess the physical activity of students with Gastrocnemius tightness or hallux valgus deformity. This data will be collected and analysed by using IBM Statistical Package for Social Science (SPSS) software.

3.10 DATA ANALYSIS

Microsoft Excel and IBM Statistical Package for Social Science (SPSS) software version 26.0 are utilized to analyse the collected data. Descriptive statistics will be used to examine the demographic data, which will include height, age, and body weight. The results will be provided as frequency, percentage, mean (M), and standard deviation (SD). The relationship between Gastrocnemius tightness and Hallux Valgus Deformity will be determined by Pearson Correlation, while the statistical significance of the association between Hallux Valgus Deformity, Gastrocnemius tightness, and physical activity will be analysed using Pearson Chi-Square. The significant value will be reported with a p value set at $p<0.05$.

Pearson's product-moment correlation coefficient (r) is a statistical measure that quantifies the strength and direction of the linear relationship between two variables. The correlation coefficient r ranges from −1 to 1, where the value indicates the strength and direction of the correlation (Newcastle University, 2023). The table 1 below describes the interpretation of r:

R value	**Interpretation**
$r = 1$	Perfect positive linear correlation.
$1 > r \geq 0.8$	Strong positive linear correlation.
$0.8 > r \geq 0.4$	Moderate positive linear correlation.
$0.4 > r > 0$	Weak positive linear correlation.
$r = 0$	No correlation.
$0 > r \geq -0.4$	Weak negative linear correlation.
$-0.4 > r \geq -0.8$	Moderate negative linear correlation.
$-0.8 > r > -1$	Strong negative linear correlation.
$r = -1$	Perfect negative linear correlation

Table 3.1: R Value Interpretation

CHAPTER 4

4.0 RESULTS

4.1 CHAPTER OVERVIEW

The results of the research project's data collection procedure are presented in this chapter. Data was gathered from 212 UTAR Sungai Long students in total.

Data of the participants' demographics were reported using descriptive statistics. The findings of the inferential tests, the evaluation and classification of the outcome measures, and, finally, the hypothesis testing are then explained. There is a brief discussion of the results, followed by a tabulation of the data.

4.2 DEMOGRAPHIC DATA OF THE PARTICIPANTS

In the 5 weeks' data collection duration, a total of 219 undergraduate students were recruited through convenience sampling in UTAR Sungai Long. 7 of them were excluded from the study due to previous injury at lower limb or ankle and knee pain. The demographic information of the participants is presented in this subsection through a combination of descriptive information, graphs, and a summary table that successfully draws attention to the most important facts of the whole section.

4.2.1 Age

The age distribution of the study's participants is shown in Figure 4.1, where the mean age was 21.05 ± 1.179 (Table 4.1). With a count of 1, the youngest participant, who was 17 years old, made up 0.5% of the sample. 47.6% (101 participants) of the participants were 21 years of age or older, with 18.9% (40 people) being 22 years of age or older. Table 4.1 shows the whole age distribution of participants.

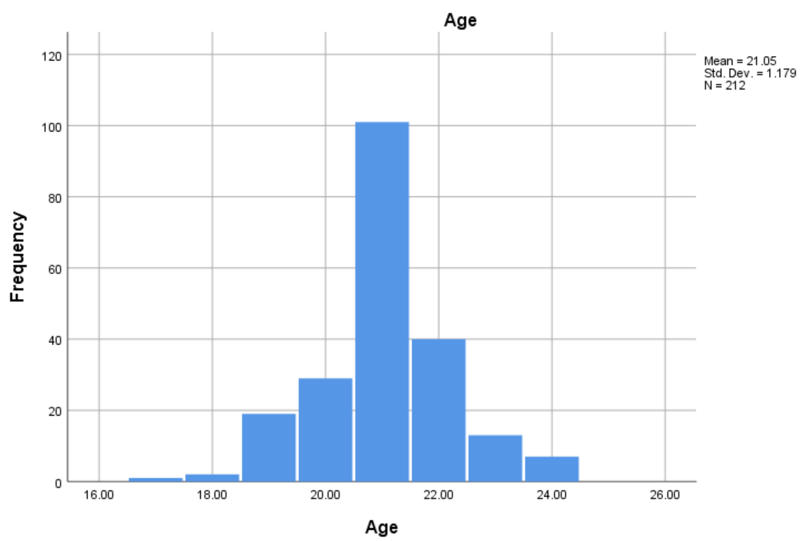

Figure 4.1: Age of Participants

4.2.2 Gender

The gender distribution of study participants is shown in Figure 4.2. Table 4.1 shows that 159 of the participants were female, making up 75% of the total, while 53 of the participants were male, making up 25%.

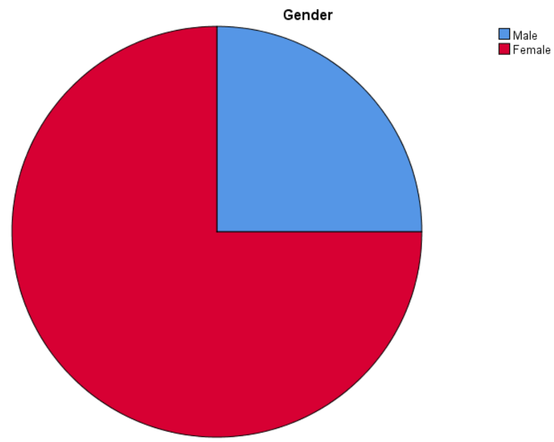

Figure 4.2: Gender of Participants

4.2.3 BMI

With a mean BMI of 21.46 ± 3.58, the participants' BMI categories are shown in Figure 4.3. It was determined that most of the participants had a "Normal Weight" (n = 150, 70.8%). Following this, 36 participants (17%) of the total were categorized as underweight. 19 participants (9%) were also classified as overweight, and seven participants (3.3%) as obese.

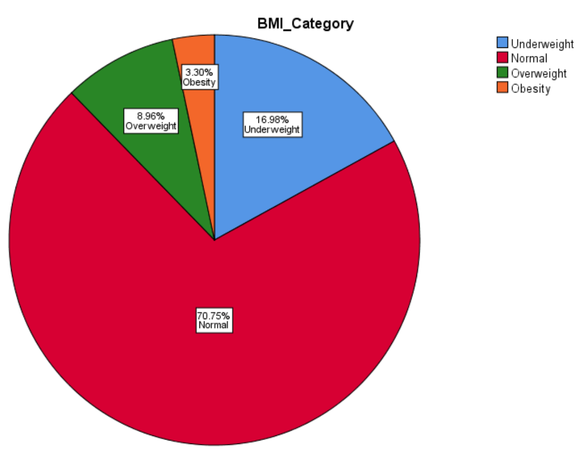

Figure 4.3: BMI Category of Participants

4.2.4 Summary of Demographic Data

Demographic data				
Demographic Variables	**Subcategory**	**Mean ± SD**	**Frequency (n)**	**Percentage (%)**
Gender	**Male**		53	25
	Female		159	75
Age		21.05 ± 1.18		
BMI		21.46 ± 3.58		
	Underweight		36	17.0
	Normal		150	70.8
	Overweight		19	9.0
	Obese		7	3.3

Table 4.1: Demographic data of the participants

BMI categorization: <18.5 (Underweight), 18.5-24.9 (Normal), 25-29.9 (Overweight), 30-39.9 (Obesity) (Nuttall, 2015)

4.3 OUTCOME MEASURE

4.3.1 International Physical Activity Questionnaire (IPAQ) and Metabolic Equivalent Time (MET) Minutes

The table 4.2 below presents the results of the International Physical Activity Questionnaire (IPAQ) and MET minutes on the physical activity and sedentary behavior of the participants during the previous seven days. The majority of individuals (n = 158, 74.5%) did not participate in vigorous physical exercise, and those who did for an average of 0.52 ± 0.99 days did so for approximately 19.93 ± 40.89 minutes per day. On average, 104 of participants (49.1%) engaged in moderate physical activity for 1.25 ± 1.62 days and 34.43 ± 43.90 minutes per day. 95.3% of participants (n=202) walked for at least 10 minutes at a time on average for 5.21 ± 2.09) days and 70.52 ± 52.38 minutes daily. For sitting, participants reported spending an average of 333.77 ± 165.68 minutes sitting, indicating significant sedentary behavior.

Table 4.2 below also lists the total number of MET (Metabolic Equivalent Task) minutes per week for the three types of PA: walking, moderate PA, and vigorous PA. The 54 participants' mean MET minutes for vigorous PA were 336.23 ± 766.71. The mean for 104 participants with mild PA was 334.05 ± 496.10. The mean for the 202 participants who walked in was significantly higher, at 1330.51 ± 1131.81. In a total, the mean of 212 participants' MET minutes in a week is 2000.79 ± 1485.05.

Physical Activity					
Physical Activity	**Subcategory**	**Mean ± SD**	**Frequency (%)**	**MET Minutes/ week (Mean ± SD)**	**Total MET Minutes for vigorous, moderate & walking (Mean ± SD)**
					2000.79 ± 1485.05
Vigorous PA				336.23 ± 766.71	
Q1. During the last 7 days, did you do vigorous physical activities?	**Yes**		54 (25.5)		
	No		158 (74.5)		
If yes, how many days did you do vigorous physical activities?		0.52 ± 0.99			
Q2. How much time did you spend doing vigorous physical activities on one of those days? (in minutes per day)		19.93 ± 40.89			

Moderate PA				334.05 ± 496.10
Q3. During the last 7 days, did you do moderate physical activities?	**Yes** **No**		104 (49.1) 108 (50.9)	
If yes, on how many days did you do moderate physical activities?		1.25 ± 1.62		
Q4. How much time did you usually spend doing moderate physical activities on one of those days? (in minutes per day)		34.43 ± 43.90		
Walking				1330.51 ± 1131.81
Q5. During the last 7 days, did you walk for at least 10 minutes at a time?	**Yes** **No**		202 (95.3) 10 (4.7)	

If yes, on how many days did you walk for at least 10 minutes at a time?	5.21 ± 2.09
Q6. How much time did you usually spend walking on one of those days? (in minutes per day)	70.52 ± 52.38
Sitting	
Q7. During the last 7 days, how much time did you spend sitting on a weekday? (in minutes per day)	333.77 ± 165.68

Table 4.2: IPAQ and MET Minutes/ week of Participants

4.3.2 Level of Physical Activity

The distribution of 212 participants' levels of physical activity is shown in Table 4.3. Three groups were created from the population: low PA (n = 47, 22.2%), moderate PA (n = 113, 53.3%), and high PA (n = 52, 24.5%). This implies that moderate physical activity was the most common among the participants, followed by high and low levels.

Distribution of Physical Activity (PA) Level		
Level of PA	**Frequency (n)**	**Percentage (%)**
Low PA	47	22.2
Moderate PA	113	53.3
High PA	52	24.5

Table 4.3: Physical Activity Level

4.3.3 Severity of Hallux Valgus Deformity

The severity of Hallux Valgus deformity and the distribution of severity levels are shown in Table 4.4.

The mean Hallux Valgus Angle for the left and right sides of the 212 participants is shown in Table 4.4. With a standard deviation of 6.48°, the mean left HVA is 15.78°, and the mean right HVA is 15.783°, with a standard deviation of 6.82°. Table 4.4 also details the distribution of Hallux Valgus severity. Hallux

Valgus (HV) was absent in 48.1% of participants on the left side, mild in 48.1%, and moderate in 3.8%. Besides, 5.2% of the participants had moderate HV, 46.7% had mild HV, and 48.1% had no HV on the right side. There were no documented occurrences of severe HV on either side. In conclusion, the data show that the majority of subjects had mild or no Hallux Valgus, with relatively few cases exhibiting significant severity.

Distribution of Hallux Valgus (HV) Severity						
Severity	**Left HV**			**Right HV**		
	Frequency (n)	**Percentage (%)**	**Mean ± SD**	**Frequency (n)**	**Percentage (%)**	**Mean ± SD**
			15.78 ± 6.48			15.78 ± 6.82
No HV	102	48.1		102	48.1	
Mild HV	102	48.1		99	46.7	
Moderate HV	8	3.8		11	5.2	

Table 4.4: Hallux Valgus Angle and Its Severity

4.3.4 Flexibility of Gastrocnemius and Distribution of Gastrocnemius Tightness

The Table 4.5 presents data on gastrocnemius flexibility and the presence or absence of gastrocnemius tightness (GT) for both the left and right sides.

The average dorsiflexion angle for the left side among GT participants is 27.87° ± 6.65, and tightness was present in 84.4% of the sample (n=179). On the other hand, 15.6% of subjects (n=33) exhibited a mean dorsiflexion angle of 27.87° ± 6.65 without GT. On the right side, 83.0% of the sample (n=176) showed tightness, and the mean dorsiflexion angle for participants with GT is somewhat higher at 28.35° ± 7.17. The mean dorsiflexion angle of the participants without GT, who made up 17.0% of the sample (n=36), was the same as that of the participants with GT. With comparable distributions on the left and right sides, the data show that gastrocnemius tightness is highly prevalent among individuals.

Gastrocnemius Flexibility and Gastrocnemius Tightness (GT)						
Presence or Absence of GT	**Left GT**			**Right GT**		
	Frequency (n)	**Percentage (%)**	**Mean ± SD**	**Frequency (n)**	**Percentage (%)**	**Mean ± SD**
			27.87 ± 6.65			28.35 ± 7.17
Presence	179	84.4		176	83.0	
Absence	33	15.6		36	17.0	

Table 4.5: Flexibility of Gastrocnemius and Presence or Absence of GT

4.4 TEST OF NORMALITY

This study used the Kolmogorov-Smirnov method because the sample size is more than 100 (n=339). Normality test was conducted to assess the data distribution of the independent and dependent variables including PA level, HA severity, and GT. According to Table 4.6, the PA level, HA severity and GT have a p value less than 0.05 which is 0.000. This indicates that the result obtained is not normally distributed.

Outcome Measurement	**Significant**
PA level	0.000
Left HA Severity	0.000
Right HA Severity	0.000
Left GT	0.000
Right GT	0.000

Table 4.6: Normality test result

4.5 INFERENTIAL ANALYSIS

The inferential analysis carried out for the research project is presented in this subsection. The study objectives and hypotheses were assessed using the Pearson Chi-square test. The test used is described at the beginning of each section, followed by the results, and a table summarizing the findings at the end. Version 26 of IBM SPSS Statistics was used to analyze the data.

4.5.1 Association Between Hallux Valgus and Physical Activity

Table 4.7 focuses on the association between HV severity (categorized as no HV, mild HV, and moderate HV) and PA levels (low, moderate, and high) for both the left and right feet. The findings indicate that the majority of participants, regardless of HV severity, engage in moderate PA. Specifically, for the left foot, 58.8% of participants without HV reported moderate PA, while 48% and 50% of those with mild and moderate HV, respectively, fell into the same PA category. Similar patterns are observed for the right foot, where 56.9% of participants without HV and 48.5% with mild HV reported moderate PA levels. Despite these trends, the chi-square analysis revealed no statistically significant association between HV severity and PA levels for either the left or right foot, with p-values of 0.636 and 0.471, respectively.

Association Between Hallux Valgus (HV) and Physical Activity (PA)

Severity of HV		**Level of PA**					
		Low N (%)	**Moderate N (%)**	**High N (%)**	χ^2	**df**	**p value**
Left HV	**No HV**	21 (20.6)	60 (58.8)	21 (20.6)	2.639	4	0.636
	Mild HV	24 (23.5)	49 (48)	29 (28.4)			
	Moderate HV	2 (25)	4 (50)	2 (25)			

Right HV	**No HV**	24 (23.5)	58 (56.9)	20 (19.6)	3.632	4	0.471
	Mild HV	21 (21.2)	48 (48.5)	30 (30.3)			
	Moderate HV	2 (18.2)	7 (63.6)	2 (18.2)			

Table 4.7: Association Between Hallux Valgus (HV) and Physical Activity (PA)

Chi Square test was performed, level of significance p <0.05, df = degree of freedom.

4.5.2 Association Between Gastrocnemius Tightness and Physical Activity

Table 4.8 examines the relationship between the presence or absence of GT and PA levels for the left and right feet.

The majority (49.7%) individuals with left GT reported moderate physical activity, while equal percentage of participants (25.1%) reporting low and high levels. Among individuals without GT on the left side, the majority (72.7%) engaged in moderate PA, with smaller proportions in low (6.1%) and high (21.2%) PA levels. A chi-square analysis found a significant relationship between left GT and PA levels (p=0.021).

For individuals with right GT reported 50% moderate PA, 25% low PA, and 25% high PA. Among those without right GT, 69.4% participated in moderate physical activity, with lesser proportions at low (8.3%) and high (22.2%) PA levels. The chi-square analysis found no significant relationship between right GT and PA levels (p=0.051).

Association Between Gastrocnemius Tightness (GT) and Physical Activity (PA)							
Presence or Absence of GT		**Level of PA**					
		Low N (%)	**Moderate N (%)**	**High N (%)**	χ^2	**df**	**p value**
Left GT	**Presence**	45 (25.1)	89 (49.7)	45 (25.1)	7.517	2	0.019
	Absence	2 (6.1)	24 (72.7)	7 (21.2)			
Right GT	**Presence**	44 (25)	88 (50)	44 (25)	5.959	2	0.046
	Absence	3 (8.3)	25 (69.4)	8 (22.2)			

Table 4.8: Association Between Gastrocnemius Tightness (GT) and Physical Activity (PA)

****Chi Square test was performed, level of significance p <0.05, df = degree of freedom.***

4.5.3 Association Between Hallux Valgus and Gastrocnemius Tightness

The table 4.9 analyzes the association between the severity of Hallux Valgus (HV) and gastrocnemius tightness (GT), on both the left and right sides. It divides HV severity into three categories: "No HV," "Mild HV," and "Moderate HV" and analyzes the presence and absence of GT for each category.

On the left side, individuals without HV had 80.4% GT presence and 19.6% GT absence, whereas those with mild HV had 88.2% GT presence and 11.8% GT absence. 87.5% of moderate HV patients had GT, while 12.5% did not have it. The chi-square test indicates that there is no statistically significant relationship between HV severity and GT presence on the left side ($p = 0.322$). Similarly, on the right side, 79.4% of people without left HV experienced GT, compared to 88.9% in the mild HV group and 90.9% in the moderate HV group. The chi-square test also finds no statistically significant connection on the right side ($p = 0.160$).

Association Between Hallux Valgus (HV) and Gastrocnemius Tightness (GT)											
Severity of HV		**Left GT**					**Right GT**				
		Presence N (%)	**Absence N (%)**	**χ^2**	**df**	**p value**	**Presence N (%)**	**Absence N (%)**	**χ^2**	**df**	**p value**
Left HV	**No HV**	82 (80.4)	20 (19.6)	2.446	2	0.322	82 (80.4)	20 (19.6)	0.988	2	0.621
	Mild HV	90 (88.2)	12 (11.8)				87 (85.3)	15 (14.7)			
	Moderate HV	7 (87.5)	1 (12.5)				7 (87.5)	1 (12.5)			
Right HV	**No HV**	81 (79.4)	21 (20.6)	3.803	2	0.160	81 (79.4)	21 (20.6)	1.993	2	0.400
	Mild HV	88 (88.9)	11 (11.1)				85 (85.9)	14 (14.1)			
	Moderate HV	10 (90.9)	1 (9.1)				10 (90.9)	1 (9.1)			

Table 4.9: Association Between Hallux Valgus (HV) and Gastrocnemius Tightness (GT)

Chi Square test was performed, level of significance p <0.05, df = degree of freedom

4.5.4 Association Between gender and gastrocnemius tightness

The table 4.10 examines the relationship between gender and the presence or absence of gastrocnemius tightness (GT) in both the left and right legs.

For Left GT, among males, 45 individuals (84.9%) exhibited the presence of GT, while 8 individuals (15.1%) showed its absence. Similarly, among females, 134 individuals (84.3%) had GT, while 25 individuals (15.7%) did not. The chi-square (χ^2) value for the left GT was 0.012, with 1 degree of freedom (df), and the p-value was 1.0, indicating no significant association between gender and the presence of GT in the left leg.

For the right gastrocnemius tightness (Right GT), among males, 45 individuals (84.9%) exhibited the presence of GT, and 8 individuals (15.1%) showed its absence. Among females, 131 individuals (82.4%) had GT, while 28 individuals (17.6%) did not. The chi-square (χ^2) value for the right GT was 0.178, with 1 degree of freedom (df), and the p-value was 0.833, again indicating no significant association between gender and GT in the right leg.

Association Between gender and Gastrocnemius Tightness (GT)										
Gender	**Presence or Absence of GT**									
	Left GT					**Right GT**				
	Presence N (%)	**Absence N (%)**	χ^2	**df**	**p value**	**Presence N (%)**	**Absence N (%)**	χ^2	**df**	**p value**
Male	45 (84.9)	8 (15.1)	0.012	1	1.0	45 (84.9)	8 (15.1)	0.178	1	0.833
Female	134 (84.3)	25 (15.7)				131 (82.4)	28 (17.6)			

Table 4.10: Association Between gender and Gastrocnemius Tightness (GT)

Chi Square test was performed, level of significance p <0.05, df = degree of freedom.

CHAPTER 5

5.0 DISCUSSION

5.1 CHAPTER OVERVIEW

This chapter summarizes the argument over the primary findings in accordance with the research objectives, with an emphasis on the relationship between hallux valgus (HV), gastrocnemius tightness (GT), and physical activity (PA) among UTAR students. The findings are evaluated in the context of previous research, providing insights into observed patterns and their consequences. Furthermore, this chapter discusses the limitations of the study and provides recommendations for future research.

5.2 DISCUSSION

5.2.1 Prevalence of Hallux Valgus and Gastrocnemius Tightness

In this study, nearly half of university students between the ages of 17 and 25 had mild HV, with 46.7% of them having the condition in their right foot and 48.1% in their left. Nevertheless, 3.8% of left feet and 5.2% of right feet experienced moderate HV. These results are in line with earlier studies showing that HV is generally prevalent, though at different rates depending on regional and demographic factors. As an illustration, Nix et al. (2010) reported a prevalence of 58.7% in the general population, with rates rising from 23% among those over 18 years old to 35.7% among those over 65, indicating an age-related trend (Nix et al., 2010). Similarly, Cai et al. (2023) discovered a global pooled prevalence of 19%, with females presents higher rates (23.74%) than males (11.43%) (Cai et al., 2023).

The results of this study are also in line with previous research from other countries. For instance, Shraddha & Aishwarya (2024) discovered a 34% incidence of HV in South Pune, primarily among females, while Hamam et al. (2023) identified a 37.2% prevalence in Saudi Arabia. Most of them presents with mild deformity. A similar distribution of deformity severity is suggested by the study that the rates of mild HV in the left and right feet were almost the same. The modest character of the deformity in the majority of individuals is further shown by the mean HV angles of 15.78 ± 6.48 degrees for the left foot and 15.78 ± 6.82 degrees for the right foot. These findings are consistent with Cho et al. (2009), who found that mild HV was linked to decreased foot function and pain in some groups (Cho et al., 2009). In line with earlier studies, the data generally demonstrate the variability and incidence of mild HV across populations.

Besides, the study found a significant prevalence of GT, with 84.4% of participants experiencing tightness in the left leg and 83.0% in the right leg. These findings are consistent with previous research demonstrating the high prevalence of GT in a variety of populations. For example, Mohamed et al. (2022) found a prevalence of 76.6% in those with asymptomatic flat feet, with females having greater rates. Similarly, Hill (1995) found a 96.5% frequency among individuals with foot and ankle diseases, underlining the relationship between GT and lower limb dysfunction (Hill, 1995). Furthermore, the mean gastrocnemius flexibility was 27.87 ± 6.65 degrees for the left leg and 28.35 ± 7.17 degrees for the right leg, which is consistent with earlier research indicating reduced flexibility in GT participants (Baumbach et al., 2016).

5.2.2 Association Between Hallux Valgus and Physical Activity

This study found no statistically significant relationship between hallux valgus (HV) on the left foot and level of physical activity (PA) among university students ($p = 0.636$). Similarly, no significant relationship was seen between HV on the right foot and PA levels ($p = 0.471$). These showing that neither the presence nor severity of HV had a significant impact on the physical activity levels of participants.

Nevertheless, comparable findings were reported by several researchers, who found no significant association between HV and PA levels in female university students. Nishimura et al. (2014) found that, whereas certain foot problems can impact mobility, HV did not have a clear link with decreased physical activity (Nishimura et al., 2014). Similarly, other research found that younger groups, such as university students, may be less affected by foot deformities like

HV than older persons, who frequently face larger activity constraints due to these disorders (Nix et al., 2010). Furthermore, Cho et al. (2009) discovered that people with mild to moderate HV had PA levels equivalent to those without HV, even if they experienced discomfort. Furthermore, Menz et al. (2023) also found that, whereas HV is associated with pain and impaired foot function, its direct impact on PA levels is unclear.

The lack of a significant association in this study may be attributed to the predominantly mild severity of HV observed among the participants (46.7% in the right foot and 48.1% in the left foot). Mild deformities are less likely to impede mobility or physical activity participation. Furthermore, the adaptability of a young and active university student is likely to reduce the functional restrictions caused by HV (Ekwere et al., 2016). The other reason for the no significant association between HV and PA in this study could be the study's limited generalizability, as it only included university students. Previous research has revealed that elderly populations had lower activity levels and greater activity limitation due to the higher severity of HV (Nix et al., 2010). Thus, the younger age group in this study may not have the same associations as the older ones.

Besides, university students' motivation or self-efficacy in terms of physical activity may also be important. University students frequently experience varied levels of stress and motivation, which can impair their ability and willingness to engage in physical activities. According to research, college students' participation in physical exercise is significantly influenced by psychosocial aspects like motivation, mental health, and social support (Kljajević et al., 2021; Johannes et al., 2024; Murphy et al., 2019). About one-third of students at a South African university were physically inactive, according to research. Psychological conditions as stress and anxiety were positively associated with motivational elements ($p < 0.05$) (Johannes et al., 2024).

5.2.3 Association Between Gastrocnemius Tightness and Physical Activity

The study's findings indicate a substantial ($p < 0.05$) association between reduced levels of physical activity (PA), particularly in moderate and high-intensity activities, and gastrocnemius tightness (GT) in both legs. This is in line with earlier studies that emphasize how tension in the gastrocnemius affects activity levels and physical performance. It has been repeatedly demonstrated that GT affects biomechanical function, resulting in compensatory movement patterns and reducing physical activities engagement.

Hoffman et al. (2021) established a standard measure for gastrocnemius muscle tightness and found that increasing tightness is associated with decreased plantarflexion force and affect gait mechanics. These changes may force individuals with GT to adopt movement patterns that restrict engagement in higher-intensity activities (Hoffman et al., 2021). Similarly, Wang et al. (2024) found that gastrocnemius tightness affect walking biomechanics, which can lead to lower PA levels (Wang et al., 2024). Morgan et al. (2019) also discovered that those with significant GT performed badly on functional performance tests, causing a direct influence on their ability to engage in physical activities (Morgan et al., 2019). Kawano et al. (2010) also discovered that GT was associated with poor flexibility test results, which are frequently predictive of total physical activity capacity (Kawano et al., 2010).

These results have been supported by a population-based studies, which show that GT is prevalent in the elderly and linked to lower levels of activity (Chan et al., 2019). GT affects hip and knee biomechanics and reduces ankle dorsiflexion, which has a negative impact on walking, running, and other physical activities, according to Wu et al. (2020) and You et al. (2009). These changed movement patterns have the potential to decrease physical activity and increase the risk of injury (Wu et al., 2020; You et al., 2009). Additionally, musculoskeletal issues such as plantar fasciitis, heel pain, and foot pain are closely linked to GT and can result in discomfort, numbness, and further restrictions in activity (Chan et al., 2019;Ramalingam et al., 2023).

In overall, GT significantly affects mobility, physical activity levels, and gait mechanics. GT limits ankle range of motion and results in biomechanical inefficiency, and it becomes more difficult to perform moderate to vigorous activities and increases musculoskeletal pain.

5.2.4 Association Between Hallux Valgus and Gastrocnemius Tightness

The study found that no significant relationship between GT and HV severity for either foot. These findings different with theoretical models and previous research that suggested a more direct correlation between these variables.

Theoretical models and studies, such as those by Barouk (2014) and O'Reilly et al. (2021), suggest that gastrocnemius tightness exacerbates hallux valgus by increasing tension in the plantar aponeurosis, which increases valgus-deforming forces at the metatarsophalangeal joint (MTPJ) (O'Reilly et al.,2021; P. Barouk & L. Barouk, 2014). O'Reilly et al. found a strong association between a positive Silfverskiöld test (indicating gastrocnemius tightness) and the presence of hallux valgus, with 96% of the case group scoring positive. These data support the notion that GT enhances the windlass mechanism by raising plantar aponeurosis tension, which causes increased valgus forces at the MTPJ (O' Reilly et al., 2021). However, despite these theoretical and clinical connections, this study's findings were failed to replicate this significant relationship.

Besides, Mann and Coughlin hypothesized that a tight gastrocnemius could predispose individuals to hallux valgus by inducing early and greater forefoot loading. This leads to a natural tendency to externally rotate the foot, rolling over the medial border instead of progressing forward through the third rocker (toe-off phase), increasing valgus forces at the metatarsophalangeal joint (Coughlin & Jones, 2007; Perera et al., 2011). Evidence primarily comes from studies on diabetic ulcers and shows an association with hallux valgus when ankle dorsiflexion is <5 degrees. Interestingly, some clinical studies support this link if Achilles tendon tightness is defined as <10 degrees of dorsiflexion, but other studies have found no association or evidence that tightness increases hallux valgus (Perera et al., 2011).

The high prevalence of GT in those without HV in this study suggests that gastrocnemius tightness may not be a distinguishing factor in HV pathogenesis, as other variables such as genetic predisposition, foot structure, or external factors such as footwear may be more critical (Perera et al., 2011). 83% of patients had a strong family history of HV, according to Coughlin and Jones (2007), who also noted that other characteristics like longer first metatarsals, greater first ray movement, and occupational or footwear considerations were significant contributors. Further casting doubt on the relationship between GT and HV severity, they discovered that only 11% of people with moderate or severe HV had tight Achilles or gastrocnemius tendons (Coughlin & Jones, 2007).

Moreover, GT could not be the main cause but instead a secondary or compensating mechanism. In population-based studies, individual differences in anatomy and compensatory mechanisms may weaken the relationship between these variables (Jankowicz-Szymańska et al., 2022). It also means that the development of HV may be more influenced by variables other than GT, such as genetic predisposition, footwear selection, or biomechanical abnormalities (L. S. Barouk, 2014).

Another possible explanation for the differences in results compared to previous research is a difference in the demographics of the study population. Hallux valgus (HV) and gastrocnemius tightness (GT) may be independently influenced by age, level of activity, and underlying medical conditions (Coughlin & Jones, 2007; Morgan et al., 2019; Perera et al., 2011). Moreover, these variations can be influenced by differences in the methods used to evaluate GT and HV. The stated prevalence rates of GT and HV, as well as the relationships between them, may be affected by the different approach taken to quantify GT in this study compared to previous studies.

The results of this study conclude that although gastrocnemius tightness is prevalent at all severity levels of hallux valgus, there is no significant association between it and the deformity. This contrasts with earlier research that highlighted the possible significance in the development of HV.

5.3 LIMITATION OF STUDY

It is important to recognize the various limitations of this study since they could affect the validity, reliability, and generalizability of the results. First, an important limitation of the outcome measures is that the IPAQ-SF questionnaire depends on self-reported data for assessing physical activity levels. Although it is a validated instrument, the International Physical Activity Questionnaire-Short Form (IPAQ-SF) mostly depends on participants' ability to recall how active they were during the previous seven days. This dependence elevates the risk of recall bias, where people might overestimate or underestimate their levels of physical activity as a result of memory loss or social desirability bias, which could lead to inaccurate findings. Additionally, since self-reporting is subjective, respondents may perceive and respond to questions differently, which could result in conflicting findings (response bias) (Barry & Livingstone, 2006).

The Hallux Valgus Angle (HVA) measurement is another methodological limitation. Since radiographic imaging is the gold standard for assessing HVA, the non-radiographic techniques used in this study could not be as accurate (Coughlin & Jones, 2007; K. M. Lee et al., 2012). The validity of the results may be impacted by the use of non-radiographic techniques, which may lead to less accurate angle measurements, particularly in cases of mild deformity.

Limitations that are caused by the recruitment method may also affect the study's findings. Due to the limited recruitment period, only 212 students participated in this study, falling short of the target population of 294 students. The statistical power of the study may be weakened by this sample size limitations. Due to a lack of data, some patterns or associations might therefore go undetected, which would affect how widely the results can be applied. Furthermore, the study has limited applicability to the larger community of university students because it only included students from the UTAR Sungai Long Campus.

The study used a convenient sampling strategy, which is cost-effective and practical, has the potential to cause sampling bias since it may wrongly include unexpected or uncontrolled factors. This bias may include confounding variables that influence results, such as neglected lifestyle or health behaviors (Sedgwick, 2013).

Furthermore, the sample involved a gender imbalance, with 75% female (n=159) and 25% male (n=53). This uneven gender distribution limits the findings' generalizability, especially in identifying gender variations in hallux valgus prevalence, gastrocnemius tightness, and physical activity levels. For example, research has shown that females are more prone to develop hallux valgus and gastrocnemius tightness due to factors such as footwear habits and anatomical abnormalities (Nguyen et al., 2010). As a result, the higher percentage of female participants may have unfairly influenced the results, limiting their applicability to a balanced population.

5.4 RECOMMENDATION FOR FUTURE STUDY

Several suggestions for future research are given to improve the study's accuracy, reliability, and generalizability. Future study should aim for a bigger sample size with more diverse demographic features, such as gender, age group, and BMI category. This would reduce the likelihood of sample bias, increase data representativeness, and make the conclusions more generalizable. It is also recommended that participants be selected from more than one university using random or stratified sampling methods. Participants from various universities, geographical locations, and cultural backgrounds would provide a broader understanding of the prevalence and impact of hallux valgus and gastrocnemius tightness in bigger groups.

A bigger sample size would help to address the issue of overrepresentation or underrepresentation of specific groups. For example, in this study, the majority of students were classified as moderate physically active, and a significant number of participants presented gastrocnemius tightness. This concentration of specific categories may have resulted in bias, altering the study's results. As a consequence, increasing the sample size would enable a more reasonable distribution of participant characteristics, improving the accuracy and reliability of the findings.

In addition, to increase data accuracy, future research should use the International Physical Activity Questionnaire-Long Form (IPAQ-LF) rather than the Short Form. The IPAQ-LF gives more information by evaluating physical activity levels in a variety of fields, including work, transportation, household duties, and leisure activities. This added detail allows for a more precise and thorough examination of physical activity patterns, reducing the possibility of mistakes caused by self-reported data.

Furthermore, using more precise and reliable approaches is critical for measuring outcomes. Radiographic imaging should be used for Hallux Valgus Angle (HVA) tests to improve measurement accuracy because it is the gold standard for measuring HV. The use of modern tools, such as 3D scanning for foot deformities and digital inclinometers for ankle flexibility, can improve data collection accuracy and dependability.

By selecting these recommendations, future investigations can overcome the limitations indicated in this study, resulting in stronger and meaningful findings that contribute to the understanding and management of hallux valgus and gastrocnemius tightness in varied populations.

5.5 CONCLUSION

In a nutshell, this study found no significant association between hallux valgus severity and physical activity levels in university students. Furthermore, the study found no significant association between hallux valgus severity and gastrocnemius tightness. However, a significant association was found between gastrocnemius tightness and physical activity levels, with students who reported gastrocnemius tightness being more likely to engage in less physical activity. Moreover, this study found that the majority of participants had mild hallux valgus and moderate physical activity levels, with gastrocnemius tightness present in a significant proportion of the participants.

Clinically, these results highlight the importance of integrating physiotherapy intervention, such as stretching and strengthening exercises, for people at risk of GT and HV to enhance ankle flexibility, improve HV deviation, and increase physical activity levels. Furthermore, health promotion programs that target sedentary behaviors and encourage foot health assessments play an important role in minimizing the impact of these musculoskeletal diseases on the QoL of young adults. Hence, further study is needed to understand the relationship between hallux valgus, gastrocnemius tightness, and physical activity. Future research should also focus on employing more accurate measurement techniques and outcome measures to increase the reliability and accuracy of the findings.

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APPENDIX A – ETHICAL APPROVAL LETTER

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

Re: U/SERC/78-363/2024

23 September 2024

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.	The Effect of Diaphragm Muscle Exercise on Dynamic Balance among Post-COVID-19 Older Adults in Klang Valley, Malaysi	Goh Le Yi	Ms Premala a/p Krishnan	
2.	Relationship Between Cognitive Domains, Dynamic Postural Stability and Fall Risk in Elderly Individuals with Mild Cognitive Impairment: A Pilot Study	Chaw Jade Wern		
23.	Association between Gastrocnemius Tightness, Hallux Valgus and Physical Activity Among University Students	Chong Yi Xian	Ms Siti Hazirah Binti Samsuri	
24.	The Prevalence of Lower Urinary Tract Symptoms (LUTS) and Its Associated Risk Factors Among Male University Students	Gan Xinyi		

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 – INFORMED CONSENT FORM & PERSONAL DATA PROTECTION STATEMENT

ASSOCIATION BETWEEN GASTROCNEMIUS TENDON TIGHTNESS, HALLUX VALGUS AND PHYSICAL ACTIVITY AMONG UNIVERSITY STUDENTS

Universiti Tunku Abdul Rahman

M. Kandiah Faculty of Medicine and Health Sciences

Department of Physiotherapy

Bachelor of Physiotherapy (Honours)

Student Investigator: Chong Yi Xian

Department: M. Kandiah Faculty of Medicine and Health Sciences (MK FMHS)

Course Name and Course Code: UMFD3026 Research Project

Year and Semester: Y3S1

Course Coordinator: Ms. Nur Aqliliriana Binti Zainuddin

INFORMED CONSENT FORM AND INFORMATION SHEET

ASSOCIATION BETWEEN GASTROCNEMIUS TENDON TIGHTNESS, HALLUX VALGUS AND PHYSICAL ACTIVITY AMONG UNIVERSITY STUDENTS.

Dear participants,
You are invited to participate in a research study conducted by CHONG YI XIAN, from Bachelor of Physiotherapy (Hons) University Tunku Abdul Rahman (UTAR), Sungai Long Campus.

You are being asked to volunteer for this research study that is being conducted as part of the requirement to complete the above-mentioned Course.

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

Purpose of the Research Study: The purpose of this study is to examine the association between Gastrocnemius tightness, hallux valgus deformity, and physical activity among UT students. Approximately 278 individuals will participate in this study.

Procedures: If you agree to be in this study, two tests will be performed which are Hallux valgus angle (HVA) measurement and Silfverskiold test. Both tests will take 10-15 min to complete. Then, you will be asked to fill up a questionnaire regarding physical activity. The relevant data will then be collected and analyzed.

Length of participation: One-time participation only

Risks and Benefits: No risk will be involved throughout the current study. The benefits of participating in this study include increased awareness on hallux valgus deformity and Gastrocnemius tightness in enhancing life satisfaction.

Confidentiality: No information that will make it possible to identify you, will be included in any reports to the University or in any publications. Research records will be stored securely, and only approved researchers will have access to the records.

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

Contacts and Questions: If you have any questions, clarifications, concerns, or complaints, about the research, the researcher conducting this study can be contacted at 012-383 7355, or by email with chongyx21@1utar.my.

My Research Supervisor, Ms Siti Hazirah Binti Samsuri, can be contacted at 019-710 4186, or by email with hazirahs@utar.edu.my if there are any inquiries, concerns or complaints about the research and there is a wish to talk to someone other than individuals on the research team.

2. Research Participant Consent Form *

Mark only one oval.

- ◯ I have been notified by you and that I hereby understand, consent and agreed to participate in this study
- ◯ I disagree to participate in this study

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 fory purpose of fulfilling our obligations to you in respect of the purposes and all such other purposes that are related to the purposes and also in providing integrated services, maintaining and storing records. Your data may be shared when required by laws and when disclosure is necessary to comply with applicable laws.

4. Any personal information retained by UTAR shall be destroyed and/or deleted in

accordance with our retention policy applicable for us in the event such information is no longer required.

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

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

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

8. You may access and update your personal data by writing to us at ***chongyx21@1utar.my***

3. *

Mark only one oval.

- ◯ 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.

4. E-signature (Eg, Electronically s/d **FULL NAME**) *
For example: Electronically s/d CHONG YI XIAN

____

APPENDIX C – DEMOGRAPHIC DATA

SECTION A: DEMOGRAPHIC DATA

Name (same as student ID) *

Your answer

Age *

Your answer

Gender *

- Female
- Male

Height *

Your answer

Weight *

Your answer

APPENDIX D – SCREENING TEST

SECTION B: SCREENING QUESTIONNAIRE

10. 1. Do you have any severe leg injury before? (e.g fracture, dislocation) *

Mark only one oval.

- Yes
- No

11. 2. Do you have any severe foot and ankle pain? *

Mark only one oval.

- Yes
- No

12. 3. Do you have any foot trauma or surgery before? *

Mark only one oval.

- Yes
- No

13. 4. Do you have any Systemic or neurological disease? *

Mark only one oval.

- Yes
- No

14. 5. Do you have any physical disabilities? *

Mark only one oval.

- Yes
- No

APPENDIX E – IPAQ-SF

SECTION C: INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days.**
Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

15. Q1. During the last 7 days, did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling? *

    Mark only one oval.

    - Yes
    - No vigorous physical activity *Skip to question 18*

16. If yes, on how many days did you do **vigorous** physical activities? *

    Example: 5 days (If no, put '0')

    ____

17. Q2. How much time did you usually spend doing **vigorous** physical activities on one of those days? (in minutes per day) *

    Example: 120 minutes

    ____

Think about all the moderate activities that you did in the **last 7 days.** **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for **at least 10 minutes** at a time.

18. Q3. During the last 7 days, did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. *

Mark only one oval.

- Yes
- No moderate physical activities *Skip to question 21*

19. If yes, on how many days did you do **moderate** physical activities? *

Example: 5 days (If no, put '0')

---

20. Q4. How much time did you usually spend doing **moderate** physical activities on one of those days? (in minutes per day) *

Example: 120 minutes

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

21. Q5. During the last 7 days, did you **walk** for at least 10 minutes at a time? *

Mark only one oval.

- Yes
- No walking *Skip to question 24*

22. If yes, on how many days did you **walk** for at least 10 minutes at a time? *

Example: 5 days (If no, put '0')

---

23. Q6. How much time did you usually spend **walking** on one of those days? (in minutes per day) *

Example: 120 minutes

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

24. Q7. During the last 7 days, how much time did you spend **sitting** on a week day? (in minutes per day) *

Example: 120 minutes

APPENDIX F – TURNITIN REPORT

Turnitin Originality Report

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association between Gastrocnemius tightness, hallux valgus deformity and physical activity among UTAR students By Chong Yi Xian

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A. Saad, K.P. Iyengar, J. Firtzpatrick, C. Azzopardi, H. Panchal, R. Botchu. "The Linear Hallux Valgus Offset– A novel way to measure Hallux Valgus", Journal of Clinical Orthopaedics and Trauma, 2022

1% match (Janssen, Daniël MC, Antal P Sanders, Nick A Guldemond, Joris Hermus, Geert HIM Walenkamp, and Lodewijk W van Rhijn. "A comparison of hallux valgus angles assessed with computerised plantar pressure measurements, clinical examination and radiography in patients with diabetes", Journal of Foot and Ankle Research, 2014.)

Janssen, Daniël MC, Antal P Sanders, Nick A Guldemond, Joris Hermus, Geert HIM Walenkamp, and Lodewijk W van Rhijn. "A comparison of hallux valgus angles assessed with computerised plantar pressure measurements, clinical examination and radiography in patients with diabetes", Journal of Foot and