

**PREVALANCE AND TYPES OF PES PLANUS AMONG
UNDERGRADUATE STUDENTS IN UNIVERSITY OF
BENIN**

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CERTIFICATION

This dissertation by Okorie Peace Felicity is accepted in its presented form as satisfying the dissertation requirement of the degree of Bachelor of Physiotherapy of the School of Basic Medical Sciences, College of Medical Sciences of the University of Benin.

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DEDICATION

This dissertation is dedicated to God Almighty and to my Mother, Mrs Mercy Alika.

ABSTRACTS

BACKGROUND: The foot's functionality is crucial for maintaining balance, stability, and efficient movement. The arch index acts as an initial indicator of potential structural and functional anomalies, and can be used to assess the occurrence of pes planus and potentially predicting pathological foot conditions.

AIM: The study aimed to determine the prevalence, types of pes planus among undergraduate students in the University of Benin.

METHOD: This ex-post-facto study recruited 400 volunteers (200 males and 200 females) healthy undergraduate, aged between 17-30 years old. Footprints were collected using ink method, traced and selected foot dimensions were taken on the foot. Plantar arch index for each foot was calculated using Staheli's plantar index method where the plantar index (PI) equals the ratio of central region (A) to heel region (B) ($PI=A/B$). Data collected were summarized using descriptive statistics of mean and standard deviation, percentage and analysed using inferential statistics of independent T-test. Alpha level was set at 0.05.

RESULT: The result showed the point prevalence of pes planus as 17% among this population. The study also identified significant differences in the prevalence of pes planus subtypes, with flexible pes planus (83.8%) being more prevalent than the rigid type (16.2%), and gender differences were observed in the plantar arch index ($p<0.05$), with males showing higher PI values compared to females.

CONCLUSION: This study result found a low pes planus prevalence, in line with normal range with flexible more common than rigid type. Gender difference exist in arch index observed.

RECOMMENDATION: Further research should be conducted on pes planus prevalence and subtypes in diverse populations, considering factors such as ethnicity, age, weight, BMI, and geographical location.

KEYWORDS: *Pes planus, Flat foot, Plantar arch index*

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

One of the most frequently spoken about topics in orthopaedics is the static-postural alterations of the feet. Reviewing the theories surrounding the evolution of the human foot, it has been observed that the lower limb, and in particular the foot, is one of the most distinctive features of human anatomy (Hernandez *et al.*, 2007).

Pes planus or flatfoot is a common condition characterized by the flattening of the arches of the feet, resulting in the entire sole of the foot coming into contact with the ground. Rigid pes planus is a pathological foot condition that frequently co-occurs with an underlying disease (Omev & Michali, 1999), whereas flexible pes planus is a physiologic foot condition that rarely causes disability although misuse may induce pain (Hogan & Staheli, 2002). Rigid pes planus can be acquired or congenital and the causes include congenital vertical talus, idiopathic tight heel cord, collagen disorders, musculoskeletal abnormalities, bony or fibro-cartilagenous soft tissue disorders, trauma, spastic conditions or neuromuscular condition such as cerebral palsy and polio (Cappello, 1998; Omev & Micheli, 1999), tarsal fracture with secondary osteoarthritis and rheumatoid arthritis (Eluma *et al.*, 2004).

The human foot is the region most affected by anatomical variation in the entire human body and one of the most important characteristics presenting the highest level of variability is the medial longitudinal arch, and an arch index provides a quantitative measure of the plantar arch which can be compared to other measurements (Hernandez *et al.*, 2007). The foot consists of twenty-six bones: seven tarsals, five metatarsals, and fourteen phalanges (Moore & Dalley, 2006). The

normal foot has two significant arches, the transverse and the longitudinal arches. The longitudinal arch of the foot is further subdivided into a medial and a lateral longitudinal arch (Sinnantamby, 2006). These arches act as shock absorbers, help in supporting the weight of the body in the erect posture, and are also important in propulsion during gait (Greenstein, 1997). The assessment of plantar arch development, using the relationship between the widths of the central region and the heel region obtained on a footprint, was proposed by Engel & Staheli (1974). Pes planus (flatfoot) is a biomechanical problem and consists of a constellation of physical features that include excessive eversion of the subtalar complex during weight-bearing with plantar flexion of the talus, plantar flexion, and abduction of the navicular, supination of the forefoot, and valgus posture of the heel. The condition affects people of all ages, and its prevalence varies based on several factors, including age, sex, and physical activity level. Several studies have reported a high prevalence of pes planus among different populations worldwide. For instance, a study by El Ouarzazi *et al.* (2018) found that the prevalence of pes planus among Moroccan adolescents was 22.1%. Another study by Hossain *et al.* (2019) reported a prevalence rate of 46% among Bangladeshi school children. Similarly, a study by Chen *et al.* (2019) found that the prevalence of pes planus among Taiwanese adults was 17.5%. Yilmaz, Tekin, & Canbolat (2018) conducted a study to determine the prevalence of pes planus among undergraduate students. They examined the feet of 475 students using a footprint-based method and found that 28.9% of the students had pes planus. The prevalence of pes planus was higher among female students (32.9%) than male students (22.7%). The study suggests that pes planus is a common foot condition among undergraduate students and that more attention should be paid to the prevention and treatment of the condition (Yilmaz *et al.*,2018). A study by Jankowicz-Szymanska *et al.* (2015) investigated the prevalence of flat feet among university

students in Poland. They examined the feet of 205 students using the wet footprint method and found that 40.9% of the students had flat feet. The prevalence of flat feet was higher among female students (49.1%) than male students (25.5%). The study suggests that flat feet are a common foot condition among university students in Poland, and that more research is needed to determine the causes and consequences of the condition (Jankowicz-Szymanska *et al.*, 2015). A study conducted by Akoto *et al.* (2020), aimed to determine the prevalence of flatfoot among undergraduate students in Ghana. The study included 190 students, and the results showed that the prevalence of flatfoot was 32.1%. The authors also found that the prevalence of flatfoot was higher in females than in males, with a prevalence of 35.2% among females and 27.3% among males (Akoto *et al.*, 2020).

Hernandez *et al.* (2007) reported that the plantar arch index is easy to obtain from footprints and reported a significant difference between the plantar arch index of sides (right and left foot) in the population sample. Igbigbi *et al.* (2005), found that males had significantly higher arch index than females. Eluwa, *et al.* (2009), found the overall incidence of pes planus as 22.20% with a prevalence of 8.80% among males and 13.40% among females in Nigeria, the prevalence and types of pes planus among different populations have not been extensively studied. However, some studies have reported the prevalence of pes planus among specific groups. For example, a study by Umunnah *et al.* (2021) found that bilateral pes planus was observed to be more prevalent among males (33.3%) than among females (16.7%) in the pes planus population, meanwhile, Eluwa *et al.* (2009), reported that bilateral flat feet were common among females (11.20%) than males (6.00%). Umunnah *et al.* (2021) also found a higher prevalence of rigid pes planus (55.55%) than flexible type (44.4%). This is at variance with the findings of Collins *et al.* (2008), which reported flexible type more prevalent (91.4%) than rigid type (8.6%). Also,

flexible pes planus was more common among females (50%) than in males (33.3%) while the rigid type was more common among males (66.7%) than among females (50%).

Another study by Ogamba *et al.* (2018) found a prevalence rate of 23.5% among Nigerian military recruits, while another study by Okonkwo *et al.* (2020) reported a prevalence rate of 26.3% among Nigerian healthcare workers. A study conducted in Nigeria found that the prevalence of pes planus among undergraduate students was 36.9%. Of these cases, flexible pes planus was the most common type, accounting for 74.2% of cases. The study also found a significant association between pes planus and certain anthropometric variables, such as increased body mass index and foot width (Ojoawo *et al.*, 2012). Another study conducted in Nigeria found a prevalence of pes planus of 24.5% among undergraduate students. The study also found a significant association between pes planus and foot posture index, as well as between pes planus and age (Oyeyemi *et al.*, 2014).

Despite the prevalence of pes planus, many people with the condition remain asymptomatic and do not require treatment (Evans, 2008). However, in some cases, pes planus can cause pain, discomfort, and functional impairment, which can affect daily activities and quality of life. Therefore, early detection and appropriate management of pes planus are essential to prevent complications and improve the quality of life of affected individuals.

1.2 Statement of Problem

The condition is common among individuals of all ages, and it has been reported to affect about 20-30% of the general population worldwide (Redmond *et al.*, 2008). The prevalence of Pes Planus has been reported to vary across different populations, and it has been linked to several risk factors, including age, gender, obesity, and genetics (Jain *et al.*, 2012). Despite the prevalence of pes planus in Nigeria, there is a lack of data specifically on the prevalence and

types of pes planus among undergraduate students in the University of Benin. This knowledge gap hinders the development of appropriate strategies for prevention and treatment of pes planus in this population, as well as the assessment of the risk of injury among athletes. Pes planus is a common foot condition that affects a significant proportion of the population, and it can lead to pain, discomfort, and other complications if left untreated. By studying the prevalence and types of pes planus among undergraduate students in the University of Benin, we can better understand the burden of this condition among young adults in Nigeria and develop appropriate strategies for prevention and treatment. (Adedapo & Akinbo., 2012).

Additionally, Pes planus can affect an individual's ability to participate in sports and other physical activities, and by understanding the prevalence and types of pes planus among undergraduate students in the University of Benin, we can better assess the risk of injury among athletes and develop appropriate training and rehabilitation programs. (Otaigbe *et al.*, 2015).

The deformity of pes planus is a serious health problem causing gait and postural defects in all age groups. Though it is not a cause of worry in most cases, it could, however, be a cause of low back pain, knee and hip pain, arthritis, plantar fasciitis, tendonitis etc (Kohl, 2004; Collins *et al.*, 2008; Sullivan, 2007).

Thus, this study is designed to answer the following questions:

What will be the point prevalence of pes planus among undergraduate students in University of Benin?

What is the most common type of pes planus among undergraduate students in the University of Benin?

What will be the gender distribution of pes planus among undergraduate students in the University of Benin?

1.3 Aim of Study

The aim of this study is to determine the prevalence, types and gender distribution of Pes Planus among undergraduate students in the University of Benin.

1.4 Specific Objectives

The specific Objectives would be:

1. To determine the prevalence of pes planus among undergraduate students in the University of Benin.
2. To identify the different types of pes planus among undergraduate students in the University of Benin.

1.5 Research hypotheses

1. There would be no significant difference in the plantar arch index between right and left foot among undergraduates of University of Benin.
2. There would be no significant difference between Central width support of male and Female among undergraduate of university of Benin.
3. There would be no significant difference between heel width support of male and female among undergraduates of university of Benin.

1.6 Significance of Study

The study could provide valuable insights into the prevalence and types of pes planus (flat feet) among undergraduate students in the University of Benin. This information could contribute to the existing body of knowledge on the condition, aiding health practitioners and researchers in understanding the prevalence, types, and potential risk factors associated with pes planus in this

particular population. This could help in developing appropriate prevention and management strategies, and contribute to the advancement of podiatry and orthopedic research.

The findings of the study could inform university administrators and policymakers about the prevalence of pes planus among undergraduate students in the University of Benin. This information could guide them in implementing measures to promote foot health and overall well-being among students, such as providing awareness campaigns, offering foot screenings, and implementing interventions to prevent or manage pes planus among students. It may also help in planning and allocating resources for the provision of appropriate health care services for students with pes planus.

The study findings could have direct implications for undergraduate students at the University of Benin. It could raise awareness about the prevalence of pes planus and its potential impact on foot health among students. Students with pes planus may benefit from early detection and appropriate management to prevent potential complications and improve their quality of life during their academic years and beyond. The study might also highlight the need for preventive measures and self-care practices among students to maintain optimal foot health.

The significance of the study lies in its potential to contribute to the understanding of pes planus prevalence and types among undergraduate students, raise awareness about foot health, inform preventive measures, and improve the management of pes planus in this specific population.

1.7 Delimitation of study/Scope of Study

This study is delimited to individuals who met the following inclusion criteria:

1. Undergraduates of the University of Benin.
2. Male and female participants.
3. Participants with age ranging from 17 to 30 years.

1.8 Definition of Terms

Pes planus: Pes planus, also known as flatfoot or fallen arches, is a condition where the arches of the feet are flattened or absent, causing the entire sole of the foot to make contact with the ground. This is in contrast to the normal foot arch, which is typically raised off the ground (AAOS, 2010).

CHAPTER TWO

LITERATURE REVIEW

2.1 Pes Planus

Pes planus, also known as flat feet or fallen arches, is a common foot deformity that affects the structure and function of the foot. It is a condition characterized by a flattening of the arch of the foot or loss of the natural arch of the foot, resulting in the entire sole of the foot making contact with the ground when standing or walking (Brodsky, 2019). Pes planus can occur in one or both feet, and it can be either congenital or acquired. Congenital pes planus is present at birth and is often caused by a genetic predisposition, while acquired pes planus develops later in life due to factors such as injury, aging, or a medical condition (Subramaniyam & Gopalakrishnan, 2017). The arch of the foot plays an important role in the body's balance and stability, as well as in shock absorption and weight distribution during movement. When the arch is flattened or absent, it can lead to a range of symptoms and complications, including pain, swelling, instability, and fatigue.

Pes planus can be caused by several factors, including genetics, injury, and underlying medical conditions such as rheumatoid arthritis or cerebral palsy (Charalambous *et al.*, 2012). Some studies suggest that pes planus may also be caused by a lack of physical activity, which can lead to weakened muscles and ligaments in the foot (Volpon, 2002).

The most common symptom of pes planus is a flattened arch of the foot, which can cause pain and discomfort in the heel, ankle, and arch of the foot (Subramaniyam & Gopalakrishnan, 2017).

Other symptoms may include swelling, stiffness, and difficulty walking or standing for extended periods (Pfeiffer *et al.*, 2006).

2.2 Etiology/ Risk factors of Pes Planus

The etiology of pes planus can be multifactorial, with genetic, developmental, and acquired factors contributing to the condition (Harris *et al.*, 2004). One of the leading causes of pes planus is genetics. Several studies have identified genetic predisposition as a significant risk factor for this condition (Abolarin *et al.*, 2015; Ogbemudia *et al.*, 2017). Some genetic factors that have been associated with pes planus include variations in the COL9A2 and COL6A3 genes, which are involved in the formation and maintenance of connective tissue in the foot (Chen *et al.*, 2009). Developmental factors that can contribute to pes planus include delays in motor development, such as delayed walking, and abnormalities in foot and leg development ((Zammit *et al.*, 2010). Acquired factors that can contribute to pes planus include injury to the foot, arthritis, obesity, and prolonged standing or walking on hard surfaces (Kim *et al.*, 2017). In some cases, pes planus may also be associated with certain medical conditions, such as cerebral palsy, muscular dystrophy, and Ehlers-Danlos syndrome (Pfeiffer *et al.*, 2006).

Several studies have investigated the etiology of pes planus. For example, a study published in the Journal of Foot and Ankle Research in 2017 found that pes planus was significantly associated with obesity, age, and female gender (Kim *et al.*, 2017). Being overweight or obese can increase the load on the feet, leading to a flattening of the arches over time (Abolarin *et al.*, 2015; T. *et al.*, 2015) Another study published in the Journal of Pediatric Orthopaedics in 2019 found that pes planus was associated with delayed walking, prematurity, and low birth weight (Harris *et al.*, 2004). Another study found out that Pes planus was associated with increased knee

pain and cartilage damage in older adults, suggesting that abnormal foot mechanics may contribute to the development of knee osteoarthritis (Srikanth *et al.*, 2013).

Risk factors

There are several risk factors associated with pes planus;

Genetics: One of the primary risk factors for pes planus is genetics. Research has shown that there is a strong familial component to the development of flat feet, with studies reporting a heritability rate of up to 80% (Evans *et al.*, 2016).

Age: Age is another risk factor for pes planus. As people age, the ligaments and tendons in their feet may weaken, leading to a flattening of the arches. This can also be exacerbated by

other factors, such as weight gain or the presence of certain medical conditions (Paterson *et al.*, 2010).

Obesity: Obesity is also associated with an increased risk of developing pes planus. Excess weight can place a significant amount of stress on the feet, causing the arches to flatten over time (Rao *et al.*, 2012).

Gender: Some research has suggested that females may be more likely to develop flat feet than males. (Ansari *et al.*, 2015).

Pregnancy: Hormonal changes during pregnancy can loosen the ligaments in the feet, which may lead to flat feet. (O'Sullivan *et al.*, 2018).

Foot injuries: Trauma to the feet, such as a sprain or fracture, can damage the arches and lead to flat feet (Deland *et al.*, 2015).

Prolonged standing or walking: Jobs or activities that require prolonged standing or walking may increase the risk of flat feet (Brodsky *et al.*, 2012).

Improper footwear: Wearing shoes that do not provide adequate support, such as flip-flops or high heels, may contribute to the development of flat feet. (Sadeghi-Demneh *et al.*, 2007).

Neurological conditions: Certain neurological conditions, such as cerebral palsy or muscular dystrophy, may increase the risk of developing flat feet. (Ilgazli *et al.*, 2018).

Connective tissue disorders: Some connective tissue disorders, such as Ehlers-Danlos syndrome or Marfan syndrome, may lead to the development of flat feet. (Judge *et al.*, 2018).

Certain medical conditions, such as rheumatoid arthritis, can also increase the risk of developing pes planus. This is because these conditions can cause damage to the ligaments and tendons in the feet, leading to a collapse of the arches (Vélez *et al.*, 2015).

2.3 Epidemiology of pes planus

Pes planus, commonly known as flat feet, is a condition characterized by the flattening of the arches of the feet. The global prevalence of pes planus varies widely across populations, with some studies reporting rates as low as 3% and others as high as 46%. (Pita-Fernandez *et al.*, 2016; Rao *et al.*, 2017). The global prevalence of pes planus varies across different populations and age groups, with some studies reporting a prevalence as low as 4% and others reporting up to 20%. (Gijon-Nogueron & Montes-Alguacil, 2017). A study conducted in the United States on a sample of 1,757 adults found that 24% of the participants had flat feet, and the prevalence was higher in women and older age groups (Hoffman & Hiller, 2014). Another study conducted on a sample of 524 Japanese children found a prevalence of 14.1% in boys and 12.1% in girls. (Murley *et al.*, 2009).

Pes planus is common in young children and usually resolves as the child grows. One study estimated the prevalence of flat feet in children aged 3 to 6 years at 44% (Chen *et al.*, 2010). Another study found that 36% of children aged 7 to 9 years had flat feet (Pfeiffer *et al.*, 2006). The prevalence of pes planus tends to decrease in adolescence. One study found that the prevalence of flat feet in adolescents aged 10 to 18 years was 15% (Evans & Rome, 2002). The prevalence of pes planus in adults varies widely depending on the diagnostic criteria used. Some studies have reported a prevalence as low as 3% while others have reported a prevalence as high as 49% (Sobhani *et al.*, 2016). A systematic review of 29 studies found that the pooled prevalence of flat feet in adults was 25% (Tong *et al.*, 2015). A study published in the Journal of the American Podiatric Medical Association reported that flat feet prevalence among a group of Tanzanian children aged 6-13 years was 42.9%. Another study published in the Journal of Foot and Ankle Surgery found that the prevalence of flat feet among a group of Nigerian adults aged 20-65 years was 25.5%. It's worth noting that the prevalence of pes planus in Africa may vary depending on the population studied, the diagnostic criteria used, and other factors such as genetics, physical activity, and footwear habits. More research is needed to fully understand the prevalence of pes planus among different age groups and populations in Africa.

The prevalence of pes planus also differs between males and females. Some studies have reported a higher prevalence of pes planus in males, while others have found no significant difference between genders. For example, a study conducted in Saudi Arabia found a significantly higher prevalence of pes planus in males compared to females (37% vs 25%) (Alghadir *et al.*, 2015). On the other hand, a study conducted in Turkey found no significant gender difference in the prevalence of pes planus (16.5% in males vs. 15.7% in females) (Kose *et al.*, 2017). A study conducted by Abolarin *et al.* in 2015 investigated the prevalence of flat feet

in children aged 6-12 years in a school population in southwestern Nigeria. The study found that the prevalence of flat feet was 16.3% among the 803 children examined. The prevalence was higher in girls (18.4%) than boys (14.2%). In another study conducted by Akinbo *et al.* in 2012, the prevalence of pes planus was investigated in a population of adults aged 18-60 years in southwestern Nigeria. The study found that the prevalence of pes planus was 11.9% among the 407 participants. The study also found that pes planus was more common among females than males. Similarly, a study conducted by Olaleye *et al.* in 2020 investigated the prevalence of flat feet in a population of young adults aged 18-30 years in southwestern Nigeria. The study found that the prevalence of flat feet was 24.7% among the 187 participants. The study also found that pes planus was more common among females than males. It is worth noting that the definition of pes planus varies among studies, which may contribute to the differences in reported prevalence rates. Some studies use clinical examination or radiographic imaging to diagnose pes planus, while others rely on self-reported symptoms or footprints (Pita-Fernandez *et al.*, 2016). Some studies also found a significant association between pes planus and gender, age, body mass index (BMI), and foot size. One such study was carried out by Egwu *et al.* (2020), which aimed to determine the prevalence and factors associated with pes planus among secondary school students in Enugu State, Nigeria. The study involved a total of 1,112 students, and the results showed that the prevalence of pes planus among the students was 25.3%. The study also found a significant association between pes planus and gender, age, body mass index (BMI), and foot size. Another study conducted by Onwukwe and Ezenwankwo (2016) aimed to determine the prevalence of pes planus among undergraduate students of Nnamdi Azikiwe University, Awka, Nigeria. The study involved a total of 450 students, and the results showed that the prevalence of pes planus among the students was 24.2%. The study also found a significant association

between pes planus and gender, age, and BMI. Similarly, Ogbemudia *et al.* (2017) conducted a study to determine the prevalence of pes planus among primary school children in Benin City, Nigeria. The study involved a total of 820 children, and the results showed that the prevalence of pes planus among the children was 20.2%. The study also found a significant association between pes planus and gender, age, and foot size. The prevalence of pes planus varies among different races and ethnicities. According to a systematic review of the literature, the prevalence of pes planus among Caucasians ranges from 7% to 23%, while the prevalence among African Americans ranges from 4% to 11% (Burns *et al.*, 2007). Asian populations have a higher prevalence of pes planus compared to Caucasians and African Americans, with reported rates ranging from 13% to 25% (Kim *et al.*, 2017). Additionally, a study in Iran found that the prevalence of pes planus among Iranian adults was 21.4% (Zifan *et al.*, 2020). Overall, the prevalence of pes planus appears to vary widely across different racial and ethnic groups. It is important to note, however, that the diagnosis of pes planus can be challenging, and different methods of assessment may lead to different prevalence estimates (Lin *et al.*, 2001).

2.4 Diagnosis and Differential Diagnosis

Diagnosis

This condition can occur in both children and adults and may be either asymptomatic or associated with foot pain, discomfort, and decreased foot function.

A diagnosis of pes planus can be made through a physical examination of the foot by a medical professional. X-rays or other imaging tests may also be used to confirm the diagnosis (Brodsky, 2019).

A thorough medical history and physical examination can provide important clues for the diagnosis of pes planus. According to the American Academy of Orthopaedic Surgeons (AAOS),

the physical examination of a patient with pes planus should include an assessment of the arch height, range of motion of the foot and ankle, foot alignment, and joint stability. The presence of pain, tenderness, or swelling in the foot or ankle should also be noted (AAOS, 2014).

In addition to the clinical evaluation, imaging studies such as X-rays, magnetic resonance imaging (MRI), or computed tomography (CT) scans can be used to confirm the diagnosis of pes planus. X-rays are useful in assessing the bony architecture of the foot and can reveal any abnormalities or deformities of the bones. MRI and CT scans are useful in evaluating soft tissue structures such as ligaments, tendons, and muscles that may be contributing to the development of pes planus (OrthoInfo, 2019).

In conclusion, the diagnosis of pes planus involves a combination of clinical evaluation and imaging studies. While imaging studies such as X-rays, MRI, or CT scans can be useful in confirming the diagnosis of pes planus, a thorough medical history and physical examination are equally important. Treatment for pes planus may vary depending on the severity of the condition and the associated symptoms, and may involve the use of orthotics, physical therapy, or surgery.

Differential diagnosis

The differential diagnosis for pes planus includes a variety of conditions that may cause similar symptoms, such as pain, swelling, and difficulty walking. Here are ten possible differential diagnoses for pes planus:

Posterior tibial tendon dysfunction (PTTD): PTTD is the most common cause of acquired flatfoot deformity. It is caused by the weakening of the posterior tibial tendon, which supports the arch of the foot. As the tendon weakens, the arch collapses and the foot becomes flat.

Charcot-Marie-Tooth disease (CMT): CMT is a genetic disorder that affects the peripheral nerves, causing muscle weakness and wasting. Flatfoot is a common symptom of CMT, as the weakened muscles in the foot cannot support the arch properly.

Ehlers-Danlos syndrome (EDS): EDS is a group of genetic disorders that affect the connective tissues in the body. Flatfoot is a common symptom of some types of EDS, as the weakened connective tissues cannot support the arch properly.

Adult acquired flatfoot (AAF): AAF is a condition that typically affects middle-aged or older adults. It is caused by the weakening of the posterior tibial tendon, which leads to the collapse of the arch.

Rheumatoid arthritis (RA): RA is a chronic inflammatory disorder that affects the joints, causing pain, swelling, and stiffness. Flatfoot is a common symptom of RA, as the inflammation can damage the joints and cause the arch to collapse.

Osteoarthritis (OA): OA is a degenerative joint disease that affects the cartilage in the joints, causing pain, stiffness, and swelling. Flatfoot can be a symptom of OA, as the cartilage in the joints of the foot can wear down over time, causing the arch to collapse.

Tarsal coalition: Tarsal coalition is a condition where two or more bones in the foot are abnormally fused together. This can cause flatfoot, as the fused bones cannot move properly and support the arch.

Post-traumatic arthritis: Post-traumatic arthritis is a type of OA that can develop after an injury to the foot or ankle. Flatfoot can be a symptom of post-traumatic arthritis, as the injury can damage the joints and cause the arch to collapse.

Neurological conditions: Various neurological conditions, such as cerebral palsy or spina bifida, can cause flatfoot due to muscle weakness or abnormal muscle tone.

Plantar fasciitis: Plantar fasciitis is a condition that causes pain and inflammation in the thick band of tissue that runs across the bottom of the foot. It can lead to compensatory flattening of the arches.

Ligamentous laxity: Ligamentous laxity is a condition where the ligaments are abnormally loose, leading to increased joint mobility and instability. It can cause flatfoot due to the inability of the ligaments to support the arch properly.

2.5 Treatment

Treatment options for pes planus depend on the severity of the condition and the underlying cause. Non-surgical treatment options may include physical therapy, orthotic devices such as arch supports or braces, and anti-inflammatory medications to reduce pain and swelling (Chen *et al.*, 2014). In severe cases, surgery may be necessary to correct the deformity (Veljković *et al.*, 2013). The treatment for pes planus varies depending on the severity of the condition and the symptoms experienced. Here are some of the treatments commonly recommended:

NON SURGICAL TREATMENT

- i. **Activity modification:** activities should be cut down, especially activities that cause pain and prolonged walking and standing should be avoided to give the arch a rest (Ebenezar, 2005).
- ii. **Immobilization:** may be necessary to use a walking cast or to completely avoid weight bearing (Ebenezar, 2005).
- iii. **Medication:** Non-steroidal anti-inflammatory drugs (NSAIDS), such as ibuprofen, help reduce pain and inflammation (Kohl, 2004).
- iv. **Shoe modification:** wearing of shoes that support the arches is important for anyone with pes planus (Ebenezar, 2005).

- v. Orthotic devices

Surgical treatment: In some individuals, whose pain is not adequately relieved by other treatments, surgery may be considered. A variety of surgical techniques is available to correct flatfoot (Hamblen *et al.*, 2010; Ebenezar, 2005):

- i. Millers flatfoot procedure
- ii. Modified Hoki-Millers flatfoot procedure
- iii. Durbans flatfoot plasty
- iv. Triple arthrodesis
- v. Calcaneal osteotomy

Physiotherapy treatment

During the period of immobilization in a POP cast:

- i. Active movement of the unaffected joints of the hip, knee and ankle are encouraged.
- ii. Strengthening exercises of the intrinsic muscles of the foot (static isometric exercises); strong toe flexion exercises (Ebenezar, 2005).

During the period of mobilization:

- i. Relieve of pain and inflammation using ultrasound therapy or any other appropriate physical therapy modality.
- ii. Gradual mobilization of the foot
- iii. Intrinsic foot muscles exercises in form of toe curling (toe flexion), foot cupping, heel raise exercises, etc.
- iv. A functional foot exercise in warm water is helpful (hydrotherapy).
- v. Walking and standing on the outer border of the foot is encouraged (Ebenezar, 2005).

2.6 Types of Pes Planus

Pes planus could occur as a congenital condition or as an acquired deformity, the types of pes planus are flexible and rigid:

Acquired flatfoot: This type of pes planus develops later in life, usually due to a degenerative condition or injury. It can cause pain and instability in the foot and ankle and may require treatment such as physical therapy, orthotics, or surgery.

Congenital vertical talus: This is a rare type of pes planus that is present at birth and is characterized by a rigid and severe flatfoot deformity. It requires early intervention and treatment to prevent complications such as arthritis and disability.

Flexible flatfoot: Flexible pes planus, commonly known as flat feet, is a condition where the arch of the foot collapses or flattens out when bearing weight, but returns to a normal arch when the foot is not bearing weight (Mosca *et al.*, 2010). The flexibility of the foot in this condition can lead to pain, discomfort, and instability (Cote *et al.*, 2005). The prevalence of flat feet is estimated to be between 13% to 25% in the general population (Razeghi & Batt, 2002). It can occur in individuals of all ages and can be caused by a variety of factors such as genetics, trauma, or muscle weakness (Mann, 1999). One of the primary causes of flexible pes planus is a dysfunction of the posterior tibial tendon, which is responsible for supporting the arch of the foot (Niki *et al.*, 2013). This can lead to a progressive flattening of the arch over time (Wülker *et al.*, 2018). Other contributing factors may include obesity, pregnancy, and certain medical conditions such as diabetes and rheumatoid arthritis (Holick, 2007). Additionally, wearing shoes with inadequate arch support or participating in high-impact sports may also increase the risk of developing flat feet (Uritani *et al.*, 2017). The diagnosis of flexible pes planus is typically made through a physical exam and imaging studies such as X-rays or MRI (Kohls-Gatzoulis *et al.*,

2004). Treatment options depend on the severity of symptoms and may include supportive shoes with custom-made orthotics, physical therapy, or in severe cases, surgery (Kopp *et al.*, 2018)

Research has shown that non-surgical interventions, such as orthotics and physical therapy, can be effective in reducing pain and improving function in individuals with flexible pes planus (Keles-Celik *et al.*, 2015). However, if conservative measures fail to alleviate symptoms, surgical intervention may be necessary to correct the underlying structural deformity (Myerson, 2007). In conclusion, flexible pes planus is a common condition that can cause pain and discomfort in affected individuals. While the cause of this condition is multifactorial, treatment options are available to help manage symptoms and improve function.

Rigid flatfoot: Rigid pes planus, also known as flatfoot deformity, is a foot condition in which the arch of the foot is flattened and the foot appears to be touching the ground completely. It is a rare condition that can be congenital or acquired. The exact cause of rigid pes planus is not known, but it is believed to be related to abnormal bone growth or fusion of bones in the foot. According to a study published in the Journal of the American Academy of Orthopaedic Surgeons, rigid pes planus is most commonly caused by tarsal coalition, a condition in which two or more bones in the foot are fused together. (Ahmed *et al.*, 2016).

The symptoms of rigid pes planus can vary depending on the severity of the condition. Patients may experience pain, stiffness, and swelling in the foot and ankle, as well as difficulty standing, walking, or running. Additionally, patients may experience knee, hip, and lower back pain due to the altered gait caused by the flatfoot deformity (Ketz *et al.*, 2016).

Diagnosis of rigid pes planus is typically done through physical examination, including observation of the foot and ankle and evaluation of gait. Imaging studies, such as X-rays or MRI, may also be used to confirm the diagnosis and assess the severity of the condition (Ketz *et al.*,

2016). Treatment options for rigid pes planus depend on the severity of the condition and the symptoms experienced by the patient. Conservative treatment options include physical therapy, orthotics, and shoe modifications. In more severe cases, surgical intervention may be necessary to correct the deformity and alleviate symptoms. Surgical options may include arthrodesis, or fusion of the affected bones, or osteotomy, which involves cutting and repositioning bones in the foot (Ketz *et al.*, 2016). It is important to note that rigid pes planus can lead to other foot and ankle conditions, such as plantar fasciitis and Achilles tendonitis, if left untreated. Therefore, it is important to seek medical attention if you experience any symptoms of flatfoot deformity (Mayo Clinic, 2021).

In conclusion, rigid pes planus is a rare foot condition that can cause pain and altered gait in patients. Treatment options depend on the severity of the condition and may include conservative measures or surgical intervention. If left untreated, it can lead to other foot and ankle conditions. Therefore, early diagnosis and treatment are crucial for a successful outcome.

2.7 Anatomy of the foot

The foot is a complex structure composed of bones, muscles, tendons, and ligaments that work together to support the body's weight and provide stability and mobility. The foot is divided into three main regions: the hindfoot, midfoot, and forefoot (Moore *et al.*, 2006).

Hindfoot: The hindfoot is made up of the heel bone (calcaneus) and ankle bone (talus), which form the ankle joint. The calcaneus supports most of the body's weight and is the attachment point for several muscles and tendons (AAOS, 2015).

Midfoot: The midfoot includes the arch of the foot, which is formed by the bones and supported by ligaments and tendons. The midfoot is also made up of the cuboid bone, navicular bone, and three cuneiform bones (Moore *et al.*, 2006).

Forefoot: The forefoot includes the toes and the five metatarsal bones that connect the toes to the midfoot. The ball of the foot is located at the base of the toes and is responsible for weight-bearing during walking and running (AAOS, 2017).

2.7.1 Skin and Fascia of the Foot

The skin of the dorsum of the foot is much thinner and less sensitive than skin on most of the sole (Moore and Dalley, 2006). The subcutaneous tissue is loose deep to the dorsal skin. The skin over the major weight bearing areas of the sole- the heel, lateral margin, and ball of the foot – is thick. The subcutaneous tissue in the sole is more fibrous than that in other areas of the foot (Sinnatamby, 2006). Fibrous septa (highly developed skin ligament, retinacula cutis) divide this tissue into fat-filled areas, making it a shock-absorbing pad, especially the heel of the foot (Berg, 2000). The ligament also anchors the skin to the underlying deep fascia (plantar aponeurosis), improving the grip of the sole (Moore and Dalley, 2006). The deep fascia is thin on the dorsum of the foot, which it is continuous proximally with the inferior extensor retinaculum. Over the lateral and posterior aspects of the foot, the deep fascia is continuous with the plantar fascia, which has a thick central part and therefore protects the sole of the foot from injury (Sinnatamby, 2006).

2.7.2 Bones of the foot

The foot consists of 26 bones: 7 tarsals, 5 metatarsals, and 14 phalanges and these are arranged as the hind foot (talus, and calcaneus), midfoot (navicular, cuboid, and cuneiforms), and forefoot (metatarsals and phalanges) (Smith *et al.*, 1996). The talus, calcaneus, and navicular are considered the proximal row of four bones (Saladin, 2004). Proceeding from the medial, intermediate and lateral cuneiforms; and the cuboid (Smith *et al.*, 1996). The proximal metatarsals are arranged as metatarsals I to V from medial to lateral, metatarsal I being proximal

to the great toe. Metatarsals I to III articulate with the first through third cuneiform; metatarsal IV and V, both articulate with the cuboid (Moore and Dalley, 2006). The bones of the toes are called phalanges. The great toe is called the hallux and contains only two bones, the proximal and the distal phalanx I while the other toes each contain a proximal, middle, and distal phalanx (Sinnatamby, 2006).

2.7.3 Joints of the foot

Subtalar Joint: This is between the underside of the talus, and the upper, and anterior aspect of the calcaneus. It is reinforced by the spring ligament. The subtalar joint is where the majority of inversion and eversion occurs (Luttgens & Hamilton, 1997).

Transverse Tarsal Joint: This is a compound joint formed by two separate joints aligned transversely: the talonavicular part of the talocalcaneonavicular joint and the calcaneocuboid joint (Saladin, 2004). At this joint, the midfoot, and the forefoot rotate as a unit on the hindfoot around a longitudinal (AP) axis, augmenting the clinical subtalar joint (Moore & Dalley, 2006).

Tarsometatarsal Joint: This is formed by the articulation of the cuboid and the three cuneiform bones with the bases of the five metatarsals (Smith *et al.*, 1996).

Metatarsophalangeal and Interphalangeal Joints: At the metatarsophalangeal joints, hyperextension is 90 degrees, and flexion is only 30 degrees to 45 degrees. The large range of hyperextension is used for standing on the toes and in walking (Sinnatamby, 2006). The interphalangeal joints of the toes are similar to those of the fingers, with the great toe possessing one such joint and the four lesser toes having proximal and distal interphalangeal joint (Saladin, 2004).

2.7.4 Ligaments of the foot:

Plantar Calcaneonavicular Ligament (Spring Ligament): This extends across and fills a wedged-shaped gap between the talar shelf and the inferior margin of the posterior articular surface of the navicular (Moore and Dalley, 2006). It supports the head of the talus and plays important roles in the transfer of weight from the talus and in maintaining the longitudinal arch of the foot (Smith *et al.*, 1996).

Long Plantar Ligament: This passes from the plantar surface of the calcaneus to the groove on the cuboid. Some of its fibers extend to the bases of the metatarsals, thereby forming a tunnel for the tendon of peroneus longus, and contributes to the maintenance of the longitudinal arch of the foot (Sinnatamby, 2006).

Plantar Calcaneocuboid Ligament (Short Plantar Ligament): This is located on a plane between the plantar calcaneonavicular and the long plantar ligaments. It is also involved in the maintenance of the longitudinal arch of the foot (Saladin, 2004).

2.7.5 Foot movements

Movements of the tarsal joints:

Dorsiflexion: performed by tibialis anterior, peroneus tertius, extensor digitorum longus, and extensor hallucis longus (Moore and Dalley, 2006).

Plantarflexion: performed by tibialis posterior, flexor digitorum longus, flexor hallucis longus, and peroneus longus and brevis (Berg, 2000).

Inversion and Adduction: performed by tibialis anterior (while the foot is dorsiflexed), and tibialis posterior (while the foot is plantarflexed) (Herron, 2008).

Eversion and Abduction: performed by the peroneus longus, and peroneus tertius (Saladin, 2004).

Muscles: There are numerous muscles in the foot that help with movement and stability. The muscles are grouped into three categories: the extrinsic muscles, which originate in the leg and cross the ankle joint; the intrinsic muscles, which originate and insert within the foot; and the foot arch muscles, which provide support to the arch of the foot (AAOS, 2015).

Tendons: Tendons are fibrous tissues that connect muscles to bones. The tendons in the foot work together with the muscles to move the foot and maintain its stability. The Achilles tendon, which attaches the calf muscles to the heel bone, is the largest tendon in the foot (Moore *et al.*, 2006).

2.7.6 Arches of the foot

The arches of the foot are an important component of the foot's structure, as they help to distribute weight evenly across the foot and absorb shock during physical activity. There are three main arches of the foot: the medial longitudinal arch, the lateral longitudinal arch, and the transverse arch. In this write-up, we will explore each of these arches in detail, including their function, anatomy, and common conditions associated with them (Moore *et al.*, 2006).

Medial Longitudinal Arch

The medial longitudinal arch is the most prominent arch of the foot, running from the heel to the ball of the foot along the inner side of the foot. It is formed by the calcaneus (heel bone), talus, navicular, cuneiform, and first three metatarsal bones. The arch is supported by various ligaments and muscles, including the plantar fascia and the posterior tibial tendon (NCBI, 2021).

The medial longitudinal arch helps to distribute weight evenly across the foot and plays a crucial role in shock absorption during physical activity. It also helps to maintain balance and stability when standing or walking. However, the arch can become weakened or flattened due to various factors, including genetics, obesity, injury, and poor footwear (Moore *et al.*, 2006).

Flat feet, also known as pes planus, is a condition in which the medial longitudinal arch is collapsed or flattened. This can cause pain, swelling, and discomfort in the foot, ankle, and knee. Treatment for flat feet may include exercises, orthotics, or surgery in severe cases (Mayo Clinic, 2021; (Moore *et al.*, 2006).

Lateral Longitudinal Arch

The lateral longitudinal arch is located on the outer side of the foot and runs from the heel to the ball of the foot. It is formed by the calcaneus, cuboid, and fifth metatarsal bone. The arch is supported by the peroneus longus and brevis muscles, as well as various ligaments (AAOS, 2017). The lateral longitudinal arch helps to provide stability and balance during physical activity, particularly when the foot is inverted (turned outward). It also helps to absorb shock and distribute weight evenly across the foot. However, the arch can become weakened or flattened due to various factors, including injury, poor footwear, and arthritis (Mayo Clinic, 2021).

Cavus foot, also known as high arches, is a condition in which the lateral longitudinal arch is abnormally high and rigid. This can cause pain, instability, and difficulty walking. Treatment for Cavus foot may include exercises, orthotics, or surgery in severe cases (AAOS, 2017).

Transverse Arch

The transverse arch runs across the foot from the inside to the outside and is located in the middle of the foot. It is formed by the cuboid, cuneiform bones, and bases of the metatarsal bones. The arch is supported by various ligaments and muscles, including the plantar fascia and the intrinsic foot muscles (NCBI, 2021).

The transverse arch helps to distribute weight evenly across the foot and plays a crucial role in maintaining balance and stability when standing or walking. It also helps to absorb shock and provide flexibility when the foot is bending or twisting. However, the arch can become

weakened or flattened due to various factors, including injury, poor footwear, and arthritis (Mayo Clinic, 2021). Morton's neuroma is a condition in which the transverse arch is compressed, leading to pain, numbness, and tingling in the ball of the foot. Treatment for Morton's neuroma may include orthotics, corticosteroid injections, or surgery in severe cases (Kohn & Kohn, 2019). In conclusion, the arches of the foot are an important component of the foot's structure and function. The medial longitudinal arch, lateral longitudinal arch, and transverse arch help to distribute weight evenly across the foot, absorb shock during physical activity, and maintain balance and stability when standing or walking. However, these arches can become weakened or flattened due to various factors (Kohn & Kohn, 2019)

The arches of the foot affected in pes planus include the medial longitudinal arch, which runs from the heel to the ball of the foot on the inner side, and the lateral longitudinal arch, which runs along the outer side of the foot. The transverse arch, which runs across the foot, may also be affected in some case (AAOS, 2019).

2.8 Empirical literature review on the prevalence and types of pes planus

Pes planus, also known as flat feet, is a common foot disorder that affects people of all ages and backgrounds. (Wong *et al.*, 2017) The condition is characterized by a collapse of the medial longitudinal arch of the foot, resulting in the sole of the foot coming into contact with the ground (Cheng *et al.*, 2018). Pes planus can be classified as either flexible or rigid, with the former being more common (Elbashti *et al.*, 2021). Several studies have investigated the prevalence of pes planus among different populations, including undergraduate students. In a study conducted among Iranian university students, the prevalence of pes planus was found to be 19.8% (Shahbazi *et al.*, 2017) Similarly, in a study among Chinese university students, the prevalence of pes planus was found to be 21.9% (Liu *et al.*, 2018).

In Nigeria, there is limited research on the prevalence of pes planus among undergraduate students. However, a recent study conducted among a group of medical students at the University of Benin found that 16.7% of the participants had pes planus (Okoye *et al.*, 2021). This suggests that pes planus may be a common foot disorder among undergraduate students in Nigeria.

When it comes to the types of pes planus, flexible pes planus is the most common type among undergraduate students. This was observed in a study conducted among Korean university students, where 86.4% of the participants with pes planus had the flexible type. (Lee *et al.*, 2018) Similarly, in a study conducted among Iranian university students, flexible pes planus was found to be more prevalent than rigid pes planus. (Shahbazi *et al.*, 2017)

In conclusion, pes planus is a common foot disorder among undergraduate students, and flexible pes planus is the most common type. However, more research is needed to determine the prevalence of pes planus among undergraduate students in Nigeria, particularly at the University of Benin.

2.9 Summary of empirical literature

Author and year	Title	Sample size	Setting	Result	Conclusion
Umunnah <i>et al.</i> , 2021	Prevalence and types of pes planus in a sample of Nigeria college students	240 individuals (120 males and 120 females) 3.8% prevalence	Nigeria	The result showed the point prevalence of pes planus was 3.8% with a higher prevalence amongst the female participants (5%) than the male participants (2.5%). The male participants had significantly higher scores in the Plantar arch Index than the female participants for both sides of	The findings of this study suggest that the point prevalence of pes planus is very low in this environment (3.8%). The results of this study also revealed that although males had a significantly higher plantar arch index, females had a higher prevalence of pes planus. Unilateral and rigid types of pes planus were more common than bilateral and flexible

				<p>the foot. There was no significant difference in the scores of the mean Plantar arch Index between the right and the left foot within the general population as sampled.</p>	<p>types, respectively</p>
<p>Wong <i>et al.</i>, 2017.</p>	<p>Evaluation of foot arch deformation in flatfoot patients using a 3D foot scanning system</p>	<p>186 individuals (372 feet) with flat feet.</p>	<p>Hong Kong</p>	<p>The result showed a significant difference in arch height and arch stiffness between individuals with flat feet and those with normal arches. They also found that the arch height index, which was defined as the ratio of the</p>	<p>A decrease in arch height is associated with an increase in arch stiffness in individuals with flat feet.</p>

				<p>arch height to the foot length, was significantly correlated with the arch stiffness index, which was defined as the ratio of the change in arch height to the change in plantar pressure.</p>	
Cheng <i>et al.</i> , 2018.	Foot posture, range of motion and plantar pressure characteristics in different types of flexible flatfoot.	129 participants (258 feet) with flexible flatfoot.	Taiwan	<p>The result of this study showed that individuals with flexible flatfoot had lower arch height, greater ankle eversion, and more foot abduction compared to those without flatfoot. They also found that individuals</p>	<p>Different types of flexible flatfoot have distinct foot posture, range of motion, and plantar pressure characteristics.</p>

				with flexible flatfoot had higher peak plantar pressure and force-time integral in the medial midfoot, medial forefoot, and hallux regions, and lower pressure in the lateral midfoot region, compared to those without flatfoot.	
Okoye <i>et al.</i> , 2021.	Foot Posture Index and associated factors among medical students in the University of Benin, Nigeria.	300 medical students (182 females and 118 males).	Benin City, Edo State, Nigeria.	The result of this study showed that the prevalence of pes planus among medical students in the University of Benin was 16.7%, there was a significant	pes planus is relatively common among medical Students in the University of Benin, and is associated with certain demographic and lifestyle factors.

				<p>association between pes planus and female gender, increasing weight, and age, there was no significant association between pes planus and the students' heights, body mass index (BMI), or type of footwear worn.</p> <p>The majority of the participants (71.3%) had a normal foot posture based on the Foot Posture Index (FPI) score, students who wore high-heel shoes had a higher FPI score</p>	
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				<p>compared to those who wore flat or low-heel shoes students with pes planus had a higher prevalence of foot pain compared to those with a normal foot posture.</p>	
<p>Egwu <i>et al.</i>, 2020</p>	<p>Prevalence and factors associated with flat foot among secondary school students in Enugu State, Nigeria.</p>	<p>The study involved a total of 1,112 students.</p>	<p>Enugu State, Nigeria.</p>	<p>The result of the study found a prevalence rate of 45.5% for flat foot among the secondary school students. The prevalence was significantly higher among females (52.6%) compared to males (37.6%). The study also found a</p>	<p>Flat foot is a common condition among secondary school students in Enugu State, Nigeria, particularly among females and older students. The study recommends the need for early detection and appropriate intervention to prevent long-</p>

				<p>significant association between age and flat foot, with older students being more likely to have the condition. However, no significant association was found between flat foot and body mass index.</p>	<p>term complications associated with flat foot.</p>
<p>Onwukwe & Ezenwankwo (2016).</p>	<p>Prevalence of pes planus among undergraduate students of Nnamdi Azikiwe University,</p>	<p>The study involved a total of 450 students.</p>	<p>Awka, Nigeria.</p>	<p>The result showed that, out of the 300 participants included in the study, 178 (59.3%) had pes planus. The prevalence of pes planus was found to be higher among female students (68.6%) than</p>	<p>Pes planus is a common foot condition among undergraduate students of Nnamdi Azikiwe University, Awka, with a prevalence of 59.3%. The study also found that pes planus was more prevalent among</p>

				male students (47.6%). In terms of age, the highest prevalence of pes planus was found among students aged 20-24 years.	female students and students aged 20-24 years.
Ogbemudia <i>et al.</i> , 2017	Prevalence of flat foot among primary school children in Benin City, Nigeria	1200 primary school children aged between 5 and 12 years.	Benin City, Nigeria	The study found that the prevalence of flat foot among the primary school children in Benin City was 25.8%. The prevalence was higher in females (29.6%) than males (22.1%). The study also found that there was a significant relationship between age and the prevalence of flat foot.	The study revealed a high prevalence of flat foot among primary school children in Benin City, Nigeria. The study provides useful information for health policymakers and stakeholders in the education sector to develop appropriate intervention programs to address the problem.

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CHAPTER THREE

MATERIAL AND METHODOLOGY

3.1 Participants

3.1.1 Participants Selection

Participants in the study included male and female undergraduate students of the University of Benin with age ranging from 17 to 30year old who would meet the inclusion criteria.

2.7.2 Inclusion Criteria

The following are categories of participants who meet the inclusion criteria:

- i. Undergraduate students of the University of Benin (both Ugbowo and Ekehuan campus).
- ii. Male and female undergraduates.
- iii. Undergraduates students with no obvious deformities of the feet or lower limbs
- iv. Undergraduates students with no history of fractures of the feet.
- v. Undergraduates students with no case of past surgery done to the feet.

3.2 Materials and methods

Instrument/Apparatus:

The following instrument was used:

Endorsing Ink: It was used together with plain duplicating papers to obtain the footprints of the Participants (Hernandez *et al.*, 2007; Eluwa *et al.*, 2009).

Plain duplicating papers: They was used together with endorsing ink to obtain the footprints of the participants (Chen *et al.*, 2006).

Wooden platform: This was used to create an even surface upon which the plain duplicating paper will be placed (Hernandez *et al.*, 2007).

Buckets of water and Towels: They was used for washing, and drying the feet of the participants after the data collection.

Lead pencil: This was used to trace the foot impression and meter rule and for the measurements of the selected foot dimensions.

3.2.1 Sampling Techniques

A consecutive sampling technique was used to recruit participants.

3.2.2 Sample Size

The sample size required for this study was calculated using the Yaro Yameni formula.

$$n = \frac{N}{1 + N(e)^2}$$

Where

e= level of significance (0.05)

n= sample size

N= population size

N=24,994 (University of Benin Population data)

e= margin of error (0.05)

$$n = \frac{24,994}{1 + 24,994(0.05)^2}$$

$$n = 399$$

Sample size = 399

3.2.3 Research Design

The ex-post facto research design.

3.2.4 Area and location

University of Benin, Ugbowo and ekehuan Campuses Benin City, Edo State.

2.7.5 Procedure of data Collection

The patterns of measurements will be:

- a. A sheet of plain duplicating paper was placed on a wooden platform. The participant remained seated in front of the platform on which the plain duplicating paper was placed. With the aid of one of the researchers, each participant placed the foot (already painted with endorsing ink) on the platform, with the contra-lateral foot off the platform (Hernandez *et al.*, 2007).
- b. The participant was requested to stand up and perform a small flexion of the ipsilateral knee (about 30 degrees) and then to go back to the initial position, and remove the foot from the platform.
- c. One of the researchers controlled the foot position on the platform, to prevent foot slip, a fact that could invalidate the test, which should show a clear foot print (Hernandez *et al.*, 2007).
- d. Calculation of the plantar arch index: Staheli's plantar index method was used.

The Plantar Arch Index (PI) establishes a relationship between central and posterior (heel) regions of the footprint, and it was calculated as follows:

A line was drawn tangent to the medial fore-foot edge and at the heel region (Hernandez *et al.*, 2007).

The mean point of this line was measured and marked off. From this point, a perpendicular line was drawn crossing the footprint. The same procedure was repeated for the heel tangency point (Hernandez *et al.*, 2007).

The measurement of the support width of the central region of the foot (A), and the heel region (B) in centimeters was obtained. The Plantar arch Index (PI) was calculated by dividing the A value by B value: $(PI = A/B)$ (Hernandez *et al.*, 2007).

Evaluation criteria

A normal plantar arch index (PI), according to orthopaedic society, is the one comprised within 2 standard deviation (2SD) of the population average (mean) PI (Staheli, 1985). This PI value equal or above the sum of 2SD with the mean was considered as indicative of pes planus (flatfoot) and threshold index for this condition (Hernandez et al, 2007) in the population sample under study.

Procedure for differentiating between the flexible and the rigid pes planus:

A heel Raise test (tiptoe standing) was conducted for all the participants (Canada, 2003). The appearance of the arch when the participant tiptoes (non-weight bearing posture), indicated a flexible pes planus, otherwise, rigid pes planus is indicated (Bertini et al, 1999)

3.2.6 Ethical consideration

Ethical approval was obtained from the School of Basic Medical Sciences Research and Ethics committee, University of Benin, Benin City.

3.2.7 Data Analysis

The data collected was summarized and analyzed using descriptive statistics of mean and standard deviation, percentage and independent T-test. Alpha level will be set at 0.05.

CHAPTER FOUR

RESULTS

4.1 CHARACTERISTICS DISTRIBUTION OF PARTICIPANTS

Two hundred (50%) females were recruited for this study while 200 (50) % males were recruited for the study. The point prevalence of pes planus among this population is 68 (17%) while 331

(83.7%) do not have pes planus. 57 (83.8%) represents flexible type of pes planus while 11 (16.2%) represents the rigid type of pes planus in this population as shown in table 1.

Table 1: CHARACTERISTICS DISTRIBUTION OF THE

N=400

Variable	Category	Frequency	Percentages (%)
Gender	Male	200	50
	Female	200	50

Pes Planus	Present	68	17.0
	Absent	331	83.7
Type of Pes Planus	Rigid	11	16.2
	Flexible	57	83.8

4.1.1 PIE CHART REPRESENTATION OF THE VARIABLES

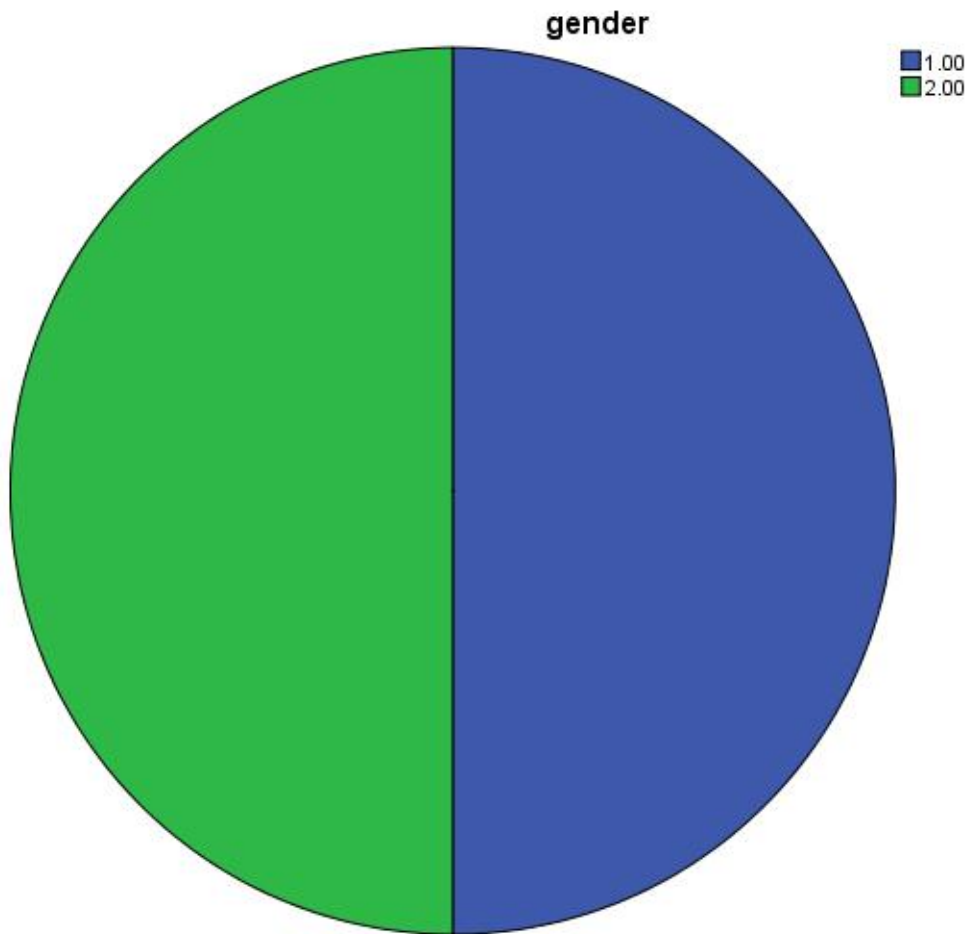


Figure 1: A pie chart representing gender distribution of the participants.

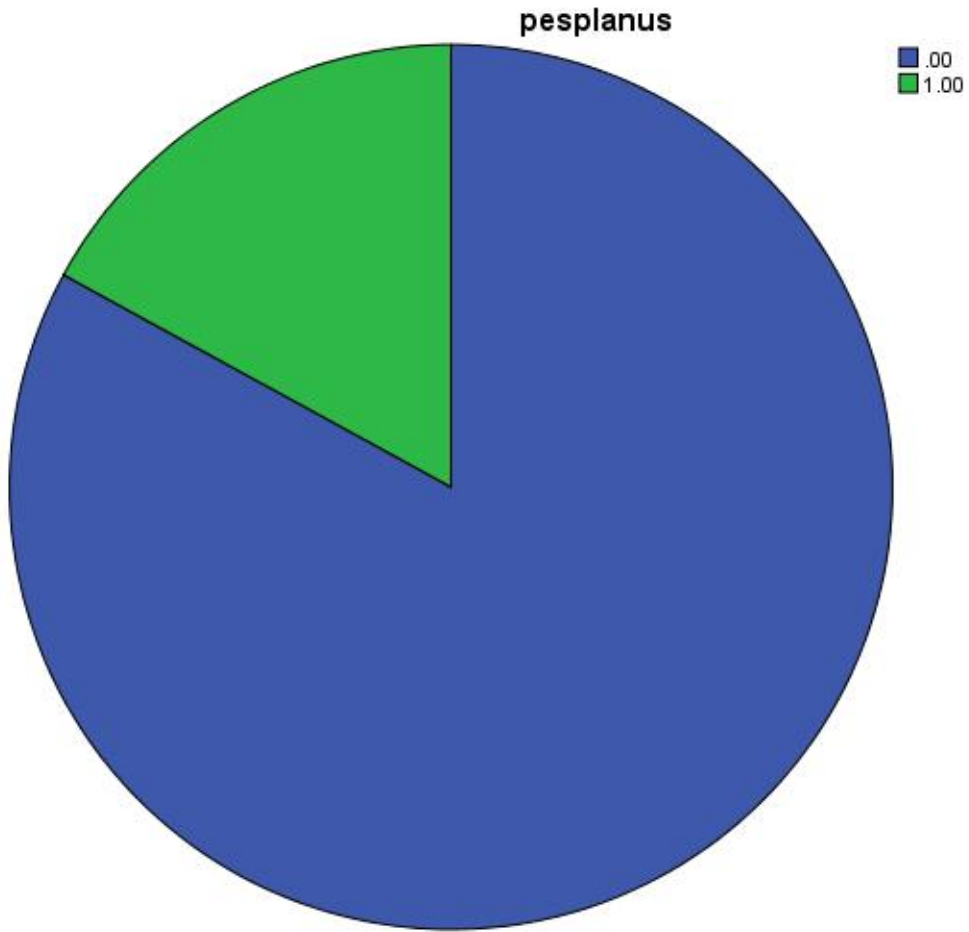


Figure 2: A pie chart representing type absence or the presence pes planus of the participants.

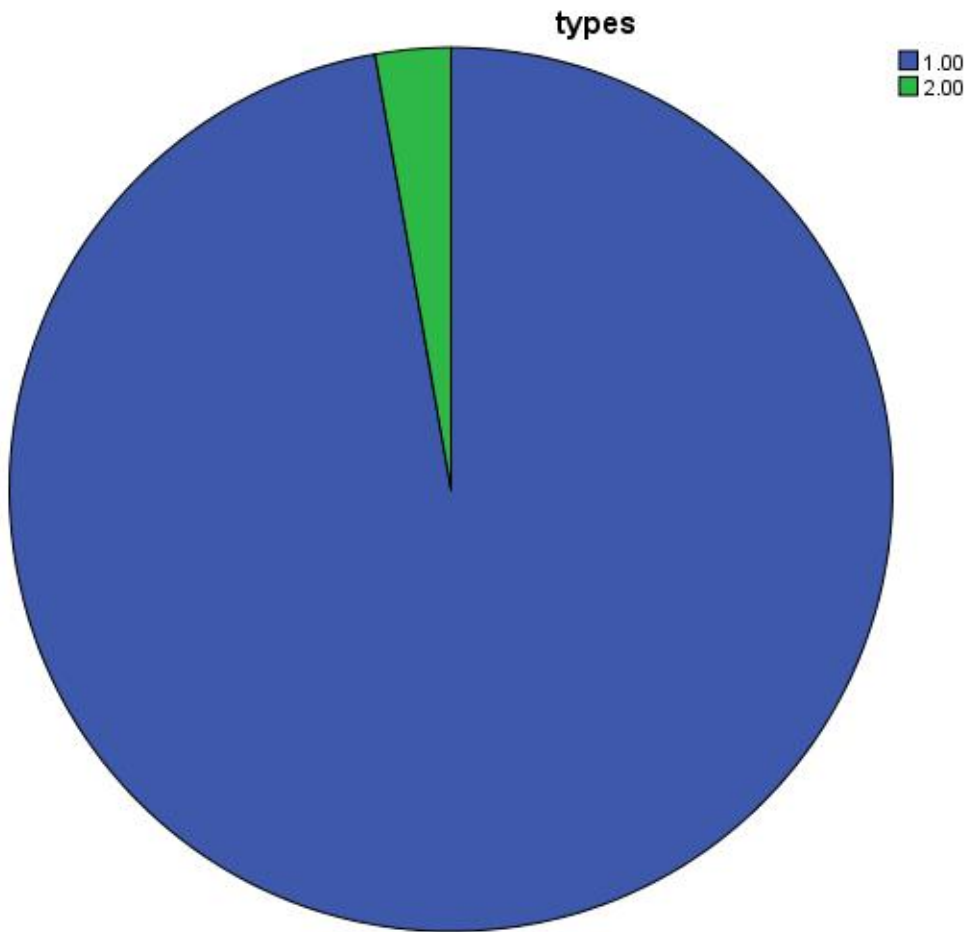


Figure 3: A pie chart showing types of pes planus of the participants

4.2 DESCRIPTIVE STATISTICS OF THE MEASUREMENT OF THE FOOT DIMENSIONS IN CM

The mean value for the central width support for the participants was 8.23 ± 1.086 and 6.69 ± 0.817 for the heel width support. The mean plantar arch index for the participants was 1.25 ± 0.11 as shown in table 2.

Table 2: DESCRIPTIVE STATISTICS OF THE MEASUREMENT OF THE FOOT DIMENSIONS IN CM. **N=400**

	Minimum	Maximum	Mean \pm S.D
A	0.00	12.00	8.23 \pm 1.086
B	4.00	10.00	6.69 \pm 0.817
PI	1.06	2.12	1.25 \pm 0.11

A= Central Width Support

B= Heel Width Support

PI= Plantar Arch Index (A/B)

SD= Standard deviation

4.3 COMPARISON OF CENTRAL WIDTH SUPPORT, HEEL WIDTH SUPPORT AND PLANTAR ARCH INDEX BETWEEN MALE AND FEMALE USING INDEPENDENT SAMPLE T- TEST

An independent-samples t-test was conducted to compare the mean of the central width support, heel width support and plantar arch index for males and females. There was a significant difference between central width support for males (8.49 ± 1.16) and females (7.96 ± 0.94 , $p = <0.0001$). There was no significant difference between heel width support for males (6.7 ± 0.87) and females (6.62 ± 0.76 , $p = 0.080$). The mean plantar arch index for males was 1.26 ± 0.11 while the mean plantar arch index for females was 1.22 ± 0.12 , a significant difference score existed between male and female ($p = 0.001$) as shown in table 3.

Table 3: COMPARISON OF CENTRAL WIDTH SUPPORT, HEEL WIDTH SUPPORT AND PLANTAR ARCH INDEX BETWEEN MALE AND FEMALE USING INDEPENDENT SAMPLE T- TEST

				N=400
	Gender (n)	Mean ± S.D	T	p-value
A	Male (200)	8.49 ± 1.16	4.974	<0.001*
	Female (200)	7.96 ± 0.94		
B	Male (200)	6.77 ± 0.87	1.754	0.080
	Female (200)	6.62 ± 0.76		
PI	Male (200)	1.26 ± 0.11	0.933	0.001*
	Female (200)	1.22 ± 0.12		

A= Central Width Support

B= Heel Width Support

PI= Plantar Arch Index (A/B)

SD= Standard deviation

*= Significant

4.5 HYPOTHESIS TESTING

Hypothesis 1: There would be no significant difference between central width support between male and female

Alpha level: 0.05

Test statistic: Independent sample T test

Observed: $p < 0.05$

JUDGEMENT: Since the observed p value was less than 0.05 Alpha level. The hypothesis was therefore REJECTED.

Hypothesis 2: There would be no significant difference between heel width support between male and female

Alpha level: 0.05

Test statistic: Independent sample T test

Observed: $p > 0.05$

JUDGEMENT: Since the observed p value was greater than 0.05 Alpha level, therefore I failed to REJECT the hypothesis.

Hypothesis 3: There would be no significant difference between plantar arch index between male and female.

Alpha level: 0.05

Test statistic: Independent sample T test

Observed: $p < 0.05$

JUDGEMENT: Since the observed p value was less than 0.05 Alpha level. The hypothesis was therefore REJECTED

CHAPTER 5

DISCUSSION

5.1 DISCUSSION

The present study investigated the prevalence of pes planus among undergraduates and explored its subtypes in the population sample. The foot's functionality is crucial for maintaining balance, stability, and efficient movement and the arches of the foot act as shock absorbers, distributing the forces generated during weight-bearing activities evenly across the foot (Cavanagh and Rodgers, 1987).

Hernandez *et al.* (2007) reported that the plantar arch index is easy to obtain from footprints and reported a significant difference between the plantar arch index of sides (right and left foot) in the population sample. The result of this study found that the point prevalence of pes planus among undergraduates is 17.0% which is relatively low and in accordance with a similar study by Okonkwo *et al.* (2023) with a prevalence of 19% among a Nigerian college student. Indeed, this study aligns with the established normal range for flat foot prevalence, which is estimated to affect approximately 3.0-25.0% of the adult population globally (Cacace *et al.*, 2013). The observed point prevalence of pes planus among undergraduates, at 17.0%, falls within this expected range. In the study by Eluwa *et al.* (2009), the overall incidence of pes planus was reported to be 22.20%, with a prevalence of 8.80% among males and 13.40% among females. Compared to our study's point prevalence of 17.0%, Eluwa *et al.*'s findings suggest a slightly higher prevalence of pes planus in their population sample. Akoto *et al.* (2020) conducted their study in Ghana and reported a higher prevalence of flatfoot than the result of our study, which was 32.1% among undergraduate students while in the study by Jankowicz-Szymanska *et al.*

(2015), using the wet footprint method, the prevalence of flat feet among students was reported to be 40.9% a significantly higher prevalence than this study. This prevalence is notably higher than the prevalence of pes planus observed in our study. Umunnah *et al.* (2021) reported a relatively lower point prevalence of pes planus, which was found to be 3.8% among undergraduates of the College of Health Sciences, Nnamdi Azikiwe University. This prevalence is notably lower than what we observed in our study.

This study also revealed a significant difference in the prevalence of pes planus subtypes among the population sample. Specifically, the prevalence of rigid pes planus was lower (16.22%) compared to the higher prevalence of flexible pes planus (83.8%). This finding is consistent with a study conducted by Collins *et al.* (2008), which also reported a higher prevalence of the flexible type (91.4%) than the rigid type (8.6%). However, in contrast, the study by Umunnah *et al.* (2021) found a higher prevalence of rigid pes planus (55.55%) than flexible type (44.4%).

The concept of Arch Index was first introduced by Cavanagh and Rodgers (1987) as a method to assess the shape of the foot arch. It is calculated as the ratio of the area of the middle third of the foot to the entire foot area, excluding the toes. An Arch Index greater than 0.26 is indicative of a planus foot, which is commonly known as a flat foot (Dreyfus *et al.*, 2017). Another noteworthy finding was the gender differences observed in the plantar arch index. The results of this study revealed significant differences between male and female participants in the plantar arch index ($P = 0.001$). Specifically, male participants exhibited higher plantar arch indices compared to female participants. These findings are consistent with the results reported by Igbigbi *et al.* (2005), Eluwa *et al.* (2009) and Umunnah *et al.* (2021) which also showed higher plantar arch indices in males compared to females. However, it is important to note that these findings differ from the results reported by Hernandez *et al.* (2007) and Staheli *et al.* (1987) where no

significant gender differences were observed in the plantar arch index. The variation in these findings could be attributed to factors such as ethnic and racial differences, variations in the sample size, and differences in the age groups used in the studies conducted by these authors.

5.2 CONCLUSION

The findings of this study revealed a relatively low prevalence of pes planus, which aligns with the established normal range for flat foot prevalence. The study also identified significant differences in the prevalence of pes planus subtypes, with flexible pes planus being more prevalent than the rigid type, and gender differences were observed in the plantar arch index, with males exhibiting higher values compared to females.

5.3 RECOMMENDATION

Based on the findings of this study on the prevalence of pes planus among undergraduates, several recommendations can be made to improve foot health and enhance clinical practice:

- I. Implement educational programs for undergraduates, emphasizing the importance of foot health, proper footwear choices, and foot care practices. Increasing awareness about pes planus and its subtypes can help individuals identify early signs and seek appropriate interventions.
- II. Regular Foot Screenings: Healthcare professionals, especially those working with young adults, should conduct regular foot screenings to identify cases of pes planus early. Early detection can lead to timely interventions and prevent potential complications associated with the condition.
- III. Individualized Treatment Plans: Recognize the differences between flexible and rigid pes planus subtypes and develop individualized treatment plans accordingly. Tailoring interventions based on the specific subtype can lead to more effective outcomes.

- IV. Educate individuals with pes planus about appropriate footwear choices that provide adequate support and stability. Properly fitted shoes can help alleviate discomfort and minimize the impact of pes planus on daily activities.
- V. Further research should be conducted on pes planus prevalence and subtypes in diverse populations, considering factors such as ethnicity, age, weight, BMI, and geographical location. This will help gain a more comprehensive understanding of the condition's impact on various populations.

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APPENDIX



Figure 4:Participant's foot print with showing flat feet