# PREVALENCE AND ASSOCIATED FACTORS OF PES PLANUS IN CHILDREN AND YOUNG ADULTS WITH DOWN'S SYNDROME AT KENYATTA NATIONAL HOSPITAL

**DR. BRIAN ODHIAMBO MOMANYI**

**ORTHOPAEDIC RESIDENT, UNIVERSITY OF NAIROBI**

**A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE UNIVERSITY OF NAIROBI FOR THE AWARD OF MASTER OF MEDICINE DEGREE IN ORTHOPAEDIC SURGERY**

# DECLARATION

I certify that this dissertation is my original work and has not been presented for a degree in any other university.

Dr Brian Odhiambo Momanyi

Orthopaedic Resident, Department of Orthopaedic Surgery

School of Medicine, University of Nairobi

H58/87540/2016

Tel: 0705 951 712 Email: docmomanyi@gmail.com

Signature: ..... Date: 01/11/2021.....

**APPROVAL BY SUPERVISORS**

**This dissertation has been submitted for examination with our full approval as supervisors.**

Josephat A.O. Mulimba

MBChB (UoN), Mmed (UoN), FRCSED, FCS (ECSA), FRSM

Professor, Department of Orthopaedic Surgery

University of Nairobi

Tel: 0722 711 217 Email: mulimba@uonbi.ac.ke

Signature _____ Date 02/11/2021.

John Kingori

MBChB (UoN), Mmed (Makerere)

Lecturer, Department of Orthopaedic Surgery

University of Nairobi

Tel 0725 979 524

Email: john.kingori@uonbi.ac.ke

Signature 

Date 5/11/21

## DEPARTMENTAL APPROVAL

This dissertation was presented at the Orthopaedic department of the University of Nairobi by Dr. Brian Odhiambo Momanyi H58/87540/2016 and is hereby approved for submission to University of Nairobi Graduate School in partial fulfilment of the requirements for the award of Master of Medicine Degree in Orthopedic Surgery.

Signature.....Date..... 9th Nov 2021

DEPT. OF ORTHOPAEDIC SURGERY
COLLEGE OF HEALTH SCIENCES
P. O. BOX 19676 - 00202
NAIROBI
TEL: 2720346 / 2725300, Ext. 43590

Vincent Muoki Mutiso

MBChB, MMed (Surgery), Certificate in Microsurgery (Hand), Fellow AO- International, FCS (ECSA )

Senior Lecturer and Chairman of the Department of Orthopaedic Surgery

University of Nairobi

P.O. Box 19681 – 00202,

Nairobi, Kenya

Email: mutiso@uonbi.ac.ke

## DEDICATION

I would like to dedicate this dissertation to my family and my wife, Dr. Martha Muthoni Gatumbu.

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## LIST OF ABBREVIATIONS AND ACRONYMS

**AP:** Anteroposterior

**BMI:** Body mass index

**CDC:** Centres for Disease Control

**C.I:** Confidence Interval

**DS:** Down's syndrome

**ENT:** Ear nose and throat

**KNH:** Kenyatta National Hospital

**MRI:** Magnetic Resonance Imaging

**UoN:** University of Nairobi

## OPERATIONAL DEFINITIONS

- **Pes planus:** also known as flat foot is a physiologic variant consisting of a decrease in the medial longitudinal arch and a valgus hindfoot and forefoot abduction with weight bearing.

- **Down's syndrome:** a chromosomal disorder characterized by an extra chromosome 21 (trisomy 21) that results in dysmorphic features and systemic complications.

- **Children and young adults with Down's syndrome:** children ages 5 years to 21years with Down's syndrome.

## ABSTRACT

**Introduction:** Pes planus, also known as flat foot, comprises of a loss of the medial longitudinal arch, a hindfoot which is in valgus and a forefoot in abduction with weight bearing. Pes planus is a common foot disorder in persons with Down's syndrome with a prevalence rate of 60% - 91% and is associated with significant morbidity. If left untreated, it can result in delay in ambulation and subsequently osteoarthritis. Down's syndrome is a chromosomal disorder which occurs frequently in humans and causes intellectual disability. Persons who have Down's syndrome are living longer today thus musculoskeletal complications that arise in childhood may have longer lasting adverse effects in adulthood and cause osteoarthritis which leads to disability. This study aims to highlight on the prevalence of flat foot in children and young adults with Down's Syndrome to inform policy/practice on routine musculoskeletal screening for this population.

**Objectives:** To establish the prevalence and associated factors of Pes planus in children and young adults with Down's syndrome of ages 5- 21 years seen at Kenyatta National Hospital.

**Methods:** This is an observational cross-sectional study conducted at Kenyatta National Hospital. The sample size for this study was 79 children and young adults with Down's syndrome attending outpatient clinics or admitted to inpatient wards in KNH. Convenient sampling was applied. After obtaining consent, a questionnaire was administered to obtain the demographic data and assess for symptoms such as delayed ambulation and abnormal gait. The feet were examined for flat foot in both non weight bearing and weight bearing position and noted to be either flexible or rigid. Lateral and AP foot x-rays in weight bearing position were ordered for all patients and those x-rays assessed for Meary's angle, calcaneal inclination angle and talonavicular coverage angle.

**Results:** Seventy-nine (79) children and young adults with Down's syndrome ages 5-21 years were enrolled in this study. The prevalence of pes planus in children and young adults with Down's syndrome was 63% (n=50) (95% CI: 51.69 to 73.86). The prevalence of flat foot was 56% (95% CI: 44 to 66.9) of the left feet examined and 52% (95% CI: 40.36 to 63.3) of the right feet examined. Flexible flat foot was present in 33 %( 95%CI: 22.7 to 44.4%) of the left feet examined and 24% (95%CI: 15.14 to 34.98) of the right feet examined. There was no statistical significance noted between age of the child (p value 0.606), gender (p value 0.713), BMI (p value 0.709), weight level (p value 0.526) and pes planus. Radiological features of pes planus were present more in left foot x-rays compared to the right foot x-rays and a lower prevalence of pes planus was noted compared to clinical examination of feet.

**Conclusion and recommendations:** The prevalence of pes planus in children and young adults with Down's syndrome was 63%. This translates to 6 out of 10 children with Down's syndrome having flat foot. Majority of the patients had flexible flat foot which was more on the left foot compared to the right foot both clinically and radiologically. There was no significant association noted between age, weight or BMI with pes planus. Routine screening of musculoskeletal disorders particularly foot disorders in children and young adults with Down's syndrome is recommended since the prevalence of flat foot particularly of the flexible type, is high and can become symptomatic subsequently.

# CHAPTER ONE

## 1.1 INTRODUCTION/ BACKGROUND

Pes planus, also known as flat foot, is a foot deformity which comprises of the loss in the medial longitudinal arch, a hind foot which is in valgus and a forefoot in abduction on weight bearing(1). Pes planus can be physiological or pathological. It occurs frequently in persons with Down's syndrome and is associated with significant morbidity (2). If left untreated, it can result in delay in ambulation and osteoarthritis with the median age of walking at 28months (2).

Down's syndrome is the most frequently occurring chromosomal disorder in humans and a major cause of intellectual disability(5). It is characterized by an additional chromosome 21 hence the name trisomy 21. The genetic mutations responsible for causing Down's syndrome include non-disjunction which occurs during fertilization and cell division when there is an additional chromosome 21 in each cell due to failure of separation of the chromosome 21 pair (6). Non-disjunction is the commonest cause of Down's syndrome occurring in 95% of the cases(6). Other genetic changes that can cause Down's syndrome are translocation and mosaicism. Translocation occurs when an additional copy of chromosome 21 is attached to a different chromosome and it accounts for 3-4% of the cases(6). This type of mutation can be passed down by the parents who may not have features of Down's syndrome but may have an extra chromosome in the eggs or sperms. This is known as balanced translocation and there is a 15% risk of the parents getting a baby with Down's syndrome. Mosaicism occurs in 1-2 % of the cases and arises where there is a mix of cells containing 46 chromosomes and some with 47 chromosomes. Genetic testing is important for making a diagnosis of Down's syndrome and ascertaining the cause in order to plan for future pregnancies(6).

Down's syndrome is characterized by phenotypic features: flat facial profile, widened nasal bridge, upward slanting eyes, hypotonia, and transverse palmar crease (Simian) crease. Additionally, children with Down's syndrome present with delayed milestones and multiple systemic complications including cardiac defects, ear nose and throat anomalies, eye defects and visual impairment, endocrine defects especially hypothyroidism, gastrointestinal complications such as constipation, duodenal atresia and Celiac disease, skin disorders like alopecia areata and blood disorders such as leukaemia(7).

Musculoskeletal disorders that occur in persons with Down's syndrome can present variably or even be asymptomatic. These include slipped capital femoral epiphysis, hip subluxation or dislocation, patella-femoral subluxation, scoliosis, cervical spine instability and other foot disorders like hallux valgus (3).These Orthopaedic manifestations that present in these children occur due to hypotonia, ligamentous laxity and joint hypermobility(4).

Routine, age-appropriate screening is recommended in persons with Down's syndrome to assess for multisystemic complications and initiate prompt treatment. Annual musculoskeletal examinations are recommended for these children and early management of orthopaedic conditions(8). In most instances, there is more attention given to the more serious complications like cervical spine instability, hip instability and slipped capital femoral epiphysis(9). However, Pes planus is a common foot disorder which needs timely screening and management including supportive footwear and orthotics to avoid delay in walking as well as long term sequelae of pain, arthritis and immobility (10).

## 1.2 PROBLEM STATEMENT

Persons with Down's syndrome are living longer today with a life expectancy of 60 years compared to 1949 when their life expectancy was 12 years. This can be attributed to advances in

medicine, awareness and management of multi-systemic complications(11). This means that musculoskeletal complications that arise in childhood may have longer lasting adverse effects in adulthood and cause arthritis which leads to disability. Therefore, it is recommended that prompt diagnosis and management of childhood foot disorders should be undertaken.

## 1.3 RESEARCH QUESTION

What is the prevalence and associated factors of pes planus in children and young adults ages 5-21 years with Down's syndrome?

## 1.4 OBJECTIVES

### 1.4.1 Broad Objective

To determine the prevalence and associated factors of Pes planus in children and young adults ages 5-21 years with Down's syndrome seen at Kenyatta National Hospital over a 3-month study period.

### 1.4.2 Specific Objectives

- To determine the prevalence of pes planus in children and young adults ages 5-21 years with Down's syndrome.
- To establish the association of Pes planus (flat foot) with age of child.
- To establish the association of Pes planus (flat foot) and BMI.
- To establish the association of Pes planus (flat foot) with symptoms (delayed walking and antalgic gait).

## 1.5 STUDY FLOW DIAGRAM

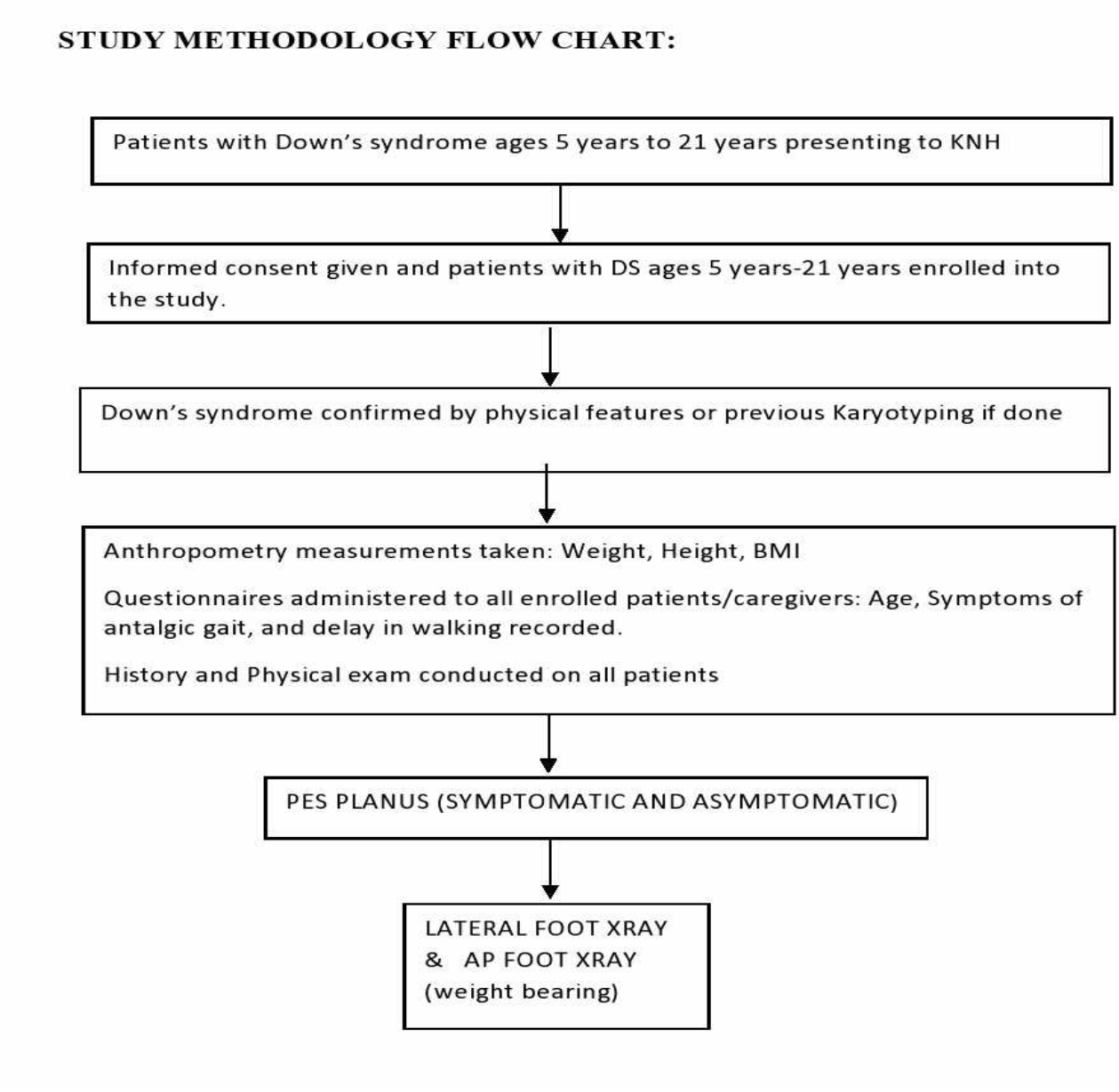


**Figure 1: The Study Methodology Flow Chart for determining Prevalence and Associated Factors of Pes Planus in Children and Young Adults with Down's syndrome**

## 1.6 STUDY JUSTIFICATION AND UTILITY

There is insufficient information on musculoskeletal complications in children with DS. The guidelines on the proper screening and management of these complications are inconsistent and variable. The American Academy of Paediatrics recommends annual musculoskeletal screening for children with Down's syndrome but this is not routine practice in other countries.

This study aims to determine the prevalence of Pes planus (flat foot) in children and young adults ages 5-21 years with Down's syndrome seen at KNH and to establish if there is an association of age, BMI, delayed ambulation and antalgic gait with pes planus. It will add to the body of knowledge on conditions that affect children with Down's syndrome locally. This study may be useful in formulating guidelines and informing policy/ practice on routine musculoskeletal screening children with DS with a view of optimizing their long-term outcomes(12).

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 INTRODUCTION

Pes planus or flat foot is a foot deformity characterized by the loss of the medial longitudinal arch of the foot on weight bearing(13). Flat foot can be classified into congenital and acquired variants. It can also be classified as flexible and rigid Pes planus. Flexible Pes planus (flat foot) describes a normal arch without bearing weight, which disappears with weight-bearing. In infants there is a fat pad under the medial longitudinal arch which protects the arch during early childhood. A normal arch will develop by age 5 or 6 years in approximately 80% of children with 20% of them with flat foot that persists into adulthood. Approximately 95% of Pes planus described in children is flexible. Pes planus especially the flexible type has been shown to improve with age. A cross-sectional study done in Nigeria among primary school students ages 6- 10 years noted the improvement of pes planus with age as follows: at age 6 years, prevalence of flat foot was 46.3%, age 7 years 29.8%, age 8 years 22.7%, age 9 years 12.4%, age 10 years 7.1%

However, in children with Down's syndrome this is rarely observed due to hypotonia and ligamentous laxity (10). Rigid Pes planus is not common. It develops during childhood but can occur at any point in life. It occurs when there is a vertical talus, accessory navicular bone, tarsal coalition or other variants of congenital hind foot pathology(13).

## 2.2 EVALUATION FOR PES PLANUS IN CHILDREN AND YOUNG ADULTS WITH DOWN'S SYNDROME

Evaluation for Pes planus in persons with Down's syndrome should begin with a history and physical examination. Age and anthropometric measurements which include weight, height and BMI should be taken. Presence of symptoms such as delayed walking and gait abnormalities should be enquired about. Of note, Pes planus is asymptomatic in most young children(13). General exam should evaluate for the phenotypic features of Down's syndrome such as flat facial profile, upward slanting palpebral fissures, widened nasal bridge, low set ears and transverse palmar (Simian) crease (7).


**Figure 2: Phenotypic Features Common in Down's syndrome: flattened nose and face with upward slanting eyes, single palmar crease, short fifth finger that curves inward and widely spaced first and second toes and increased skin creases.**

(Adapted from Lucina Foundation: Features of Down's Syndrome) (14).

Physical examination of the foot should be done systematically beginning with inspection with the patient in weight bearing position and non-weight bearing position. On inspection, flat foot should be observed. In weight bearing position, the medial longitudinal arch will disappear and reappear in non-weight bearing position. This is a flexible flat foot. See the figure below.

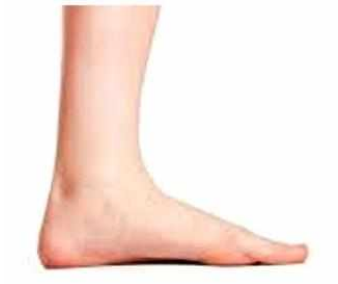

Figure 3: Flat Foot **(11)**

Over pronation is usually observed and on inspection from the back, “too many toes” sign and heel valgus is appreciated. See the figure below.


**Figure 4: Heel Valgus (2)**

Asymmetry of the feet should be observed. Palpation of the posterior tibial tendon, lateral rear foot, and plantar fascia should be done after which the range of motion is assessed to distinguish between flexible and rigid Pes planus.The Hubscher manoeuvre, also known as Jack test, can be used to determine if it is a reducible deformity. The test is performed with the patient weight bearing while the clinician dorsiflexes the hallux and watches for the formation of an arch(15).

Muscle strength assessment can be done by observing for a single toe raise. Assessment of posterior tibial tendon muscle strength is done by applying resistance on the foot while the patient inverts. Lastly evaluation of gait may reveal an antalgic gait and over pronation with ambulation(10).

Radiographic evaluation of Pes planus, from literature, is indicated only in symptomatic children or those with complicated foot disorders and includes plain radiographs and MRI(16) (17). Weight bearing lateral x-rays of the foot is the gold standard for making a diagnosis of flat foot where a Meary's angle greater than 4 degrees convex downward suggests Pes planus. Meary's angle is also known as the talus-first metatarsal angle and it is derived from the angle obtained by lines drawn from the centre longitudinal axes of the talus and metatarsal(16). It can also be used to classify the severity of deformity: mild <15°, moderate: 15-30° and severe: > 30°.

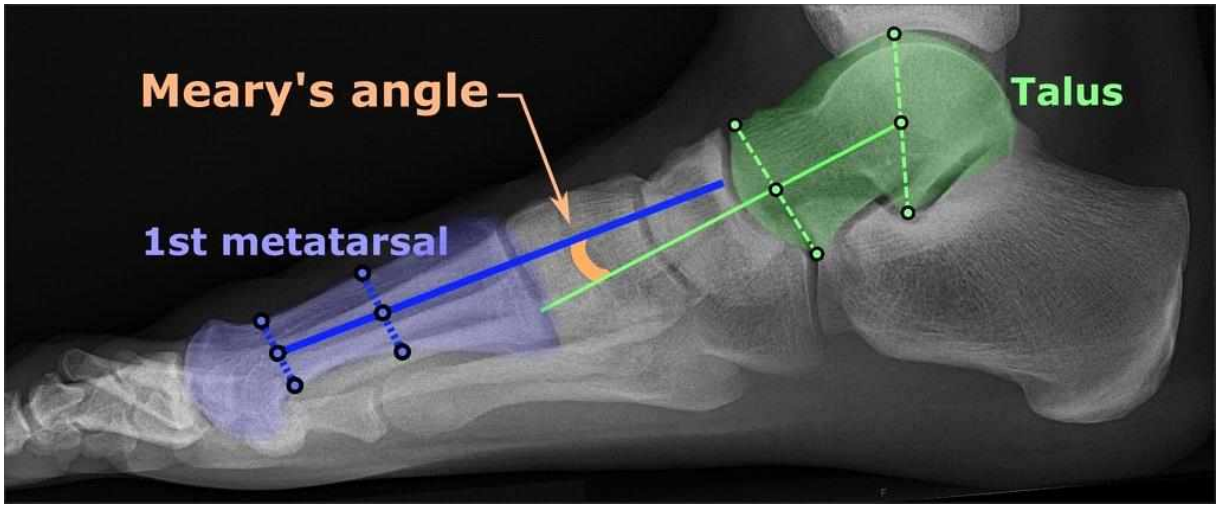


**Figure 5: Meary's Angle (18) obtained by the intersection of lines through the talus and 1st metatarsal at apex of deformity.**

A calcaneal inclination angle, also called calcaneal pitch angle, of less than 18 degrees is indicative of Pes planus(flat foot).This angle is obtained from the calcaneal inclination axis and

the horizontal surface on which the foot is placed (16).

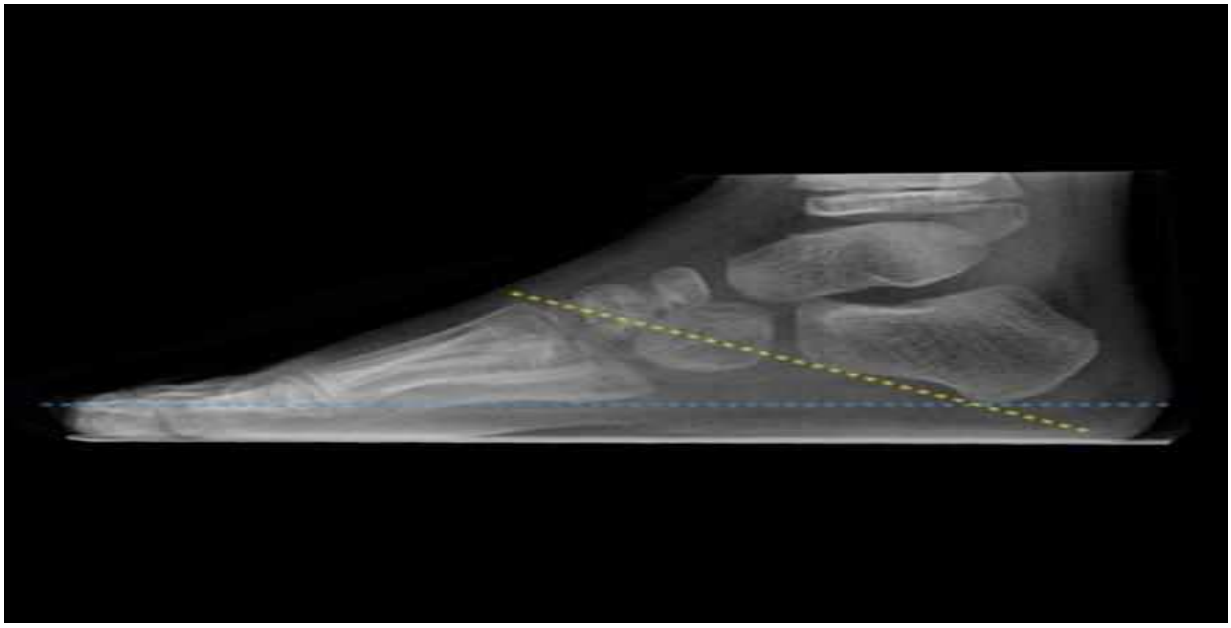

**Figure 6: Calcaneal Inclination Angle on the Lateral Weight bearing Radiograph (18)**

Talonavicular coverage angle is another measurement used to evaluate for pes planus on weight bearing AP foot radiographs. It measures the degree of lateral subluxation of the navicular on the talus or talonavicular uncoverage. The angle formed by lines connecting the articular surfaces of both the talus and navicular is the talonavicular coverage angle. An angle of greater than 7 degrees suggests lateral talar subluxation or pes planus(16).

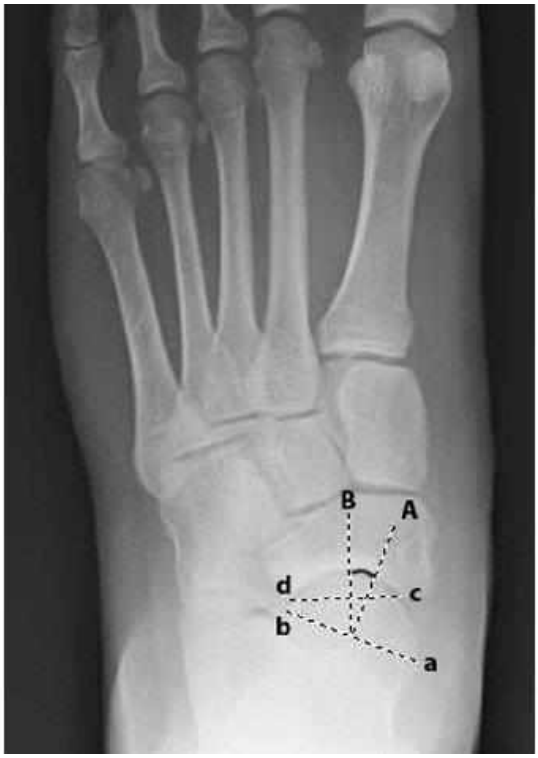


**Figure 7: Talonavicular Coverage Angle on Dorsoplantar Weight bearing Radiograph (18)**

Indications for MRI include soft tissue injury like posterior tibial tendon dysfunction or injury to the spring ligament or other supporting soft tissue structures (17).

## 2.3 PREVALENCE OF PES PLANUS IN CHILDREN AND YOUNG ADULTS WITH DOWN'S SYNDROME

The prevalence of flat foot in normal school going children has been studied in Nigeria and Ethiopia. In Nigeria, the prevalence of pes planus in normal children was 10% with a higher prevalence in girls (13%) compared to boys (7%)(18). In Ethiopia, the overall prevalence of flat foot in school aged children ages 11-15 years was 17% with a significant difference based on age, gender and BMI. This study showed that there was need to formulate a screening algorithm for diagnosis and treatment of pes planus (19).

In a prospective study investigating the relationship between flat foot and internal rotation of hip indirectly femoral anteversion in children between 3 and 6 years, the findings were that all children with flat feet had internal rotation of hip. Although there are no long term prospective studies on flat foot, its associated complications and patient reported quality of life from literature, anecdotally the complications that may arise from untreated symptomatic flat foot are pain and disability in adulthood.

The prevalence of musculoskeletal disorders in children and young adults with Down's syndrome is 20% - 23% with foot disorders accounting for 30% (3) (9). Pes planus is the commonest foot disorder in children with Down's syndrome with a prevalence rate of 91% according to an observational study done by Foley and Killeen where 503 children aged 0-21 years with DS were observed over an 18-month period. Additionally, there was delay in ambulation with the median age to walk being 28 months, but the delay could be up to 84 months due to developmental delay as well as other factors (2). Other morbidities associated with pes planus include formation of callus on pressure points, repetitive injury to ligaments and formation of bone spurs. Hindfoot valgus develops as a result of sustained calcaneal eversion which results in postural changes. These changes result in poor muscle strength with subsequent delay in ambulation. They noted that these conditions can present in variable manners or be completely asymptomatic. Pes planus is common; therefore, early consideration of orthotics and surgery where need be should be considered(2).

Perotti et al did a radiographic assessment of foot and ankle x-rays of children ages 0-14 years with Down's syndrome to describe the foot and ankle deformities (10). In this study, 581 children with Down syndrome were reviewed and 101 children (58 boys and 4 girls) who had foot and/or ankle radiographs were included in the analysis. They were then categorized into 3

groups based on which x-rays they had: foot x-rays (group I), ankle x-rays (group II) and both foot and ankle x-rays (group 3) with all the x-rays done in the standing weight-bearing position. Radiographic measurements were correlated with age, body mass index and pain. One paediatric orthopaedic surgeon reviewed all the radiographs. Pes planus was present in 46% of the patients in the study based on observation and 58% in those who had foot x-rays done. The prevalence of Pes planus was 58% in children below ten years of age, 59% in children between ten and 13.9 years of age and 57% in children above 14 years of age. This study found that the prevalence of deformities was higher on radiographic evaluations than clinical observation, but foot and ankle radiographs were only indicated for symptomatic children with pain and atypical gait(10).

Atypical gait in children with Down's syndrome includes increased base of support, increased time in double support, shorter step length, more force at terminal stance to push the foot off the ground with less efficient push off.

In a case control study comparing 50 children with DS aged 4 years to 10years and 100 normal children, the authors, Concolino et al found the prevalence of flat foot to be 60% in the DS group compared to 10% in the normal children (20). The aim of the study was to emphasize on early podiatric evaluation of persons with Down syndrome for early diagnosis and management of orthopaedic disorders(20).

The factors that contribute to musculoskeletal disorders in persons with Down's syndrome are hypotonia and joint laxity. However, an observational study by Livingstone and Hirst on orthopaedic disorders in school age children with DS found that joint laxity was not a major contributor to joint disorders in these children (21).

Annual musculoskeletal screening is recommended for children with Down's syndrome according to the American Academy of Paediatrics (8). Locally, Munyao et al in his study on age-related assessment of the status of clinical care offered to children with Down syndrome at Kenyatta National Hospital looked at 101 children with Down's syndrome aged 0-12 years and assessed the clinical care given to them in relation to the set international standards of care for children with DS. He found that there were missed opportunities in the management and follow up of these children. Age-appropriate screening tests for musculoskeletal disorders and other multisystemic complications were not done for the majority of the children(12).

In Kenya, the incidence of Down's syndrome is not known (12). In the USA, the incidence of Down's syndrome is 1 in 800 live births with approximately 6,000 children born with Down's syndrome annually (5). There is no registry specifically for children with Down's syndrome. These children are registered under the National Council for persons with disability (NCPWD). However, there are registered organizations for children and adults with Down's syndrome like the Down's syndrome Society of Kenya and T21 families group.

## 2.4 FACTORS ASSOCIATED WITH PES PLANUS IN DOWN'S SYNDROME

Pes planus or flat foot has been associated with various factors such as age of the child, BMI and symptoms such as pain, delayed walking and abnormal gait. Studies have shown that prevalence of flat foot decreased with increasing age from age 6 years, which is the critical time for plantar arch development, to 10 years. This can be attributed to the resolution and improvement of the medial arch and the reduction of the rear foot angle with age. Weight has a significant association with pes planus. Obesity in children increased the risk of flat foot three fold compared to children of normal weight. This is due to loading effects on the developing longitudinal arch of growing children. Delayed walking in children with Down's syndrome can

be attributed to neurodevelopmental delays as well as ligamentous laxity and hypotonia. These lead to decreased balance and atypical gait patterns. Developmental delays specifically for motor development are influenced by brain maturation and environmental influences. The neural pathways are involved in coordination, balance and proprioception. Lack of development of these neural pathways leads to gross motor delays like delay in ambulation. Hypotonia and hyporeflexia also influences gross motor function.

The gait pattern in children with Down's syndrome includes increased support base, prolonged time in double support, reduced length of steps and more exertion at terminal stance phase to push the foot off the ground. They also have less efficient push off due to the flat feet.

Obesity is defined by the Centres for Disease Control (CDC) as BMI of more than 95th percentile for children of the same age and gender(24). The effects of temporal loading intensity on foot biomechanics have been examined and an association between obesity and flat foot established. In normal children, obesity is associated with the collapse of medial longitudinal arch (25). An association between BMI and pes planus in children with DS has been demonstrated in literature specifically an observational study done in Israel on 475 patients with DS (26). Flat foot has been associated with symptoms such as delayed ambulation with a median age of 28months, pain and antalgic gait.

# CHAPTER THREE

## 3.1 METHODOLOGY

## 3.2 STUDY DESIGN

This was an observational cross-sectional study. Pre-designed questionnaires were administered to patients or parents / guardians of patients attending the outpatient clinics at Kenyatta National Hospital meeting the inclusion criteria. We also included all patients with Down's syndrome admitted to the inpatient wards. We evaluated for flat foot in these patients and associated factors such as age of child, BMI and the presence of symptoms such as delayed walking and gait abnormalities.

## 3.3 STUDY SITE

This study was conducted in Kenyatta National hospital (KNH) which is a national referral and teaching hospital. DS patients usually attend paediatric outpatient clinics including neurology, cardiology, endocrinology, ENT, physiotherapy and speech therapy clinics. The principal investigator and research assistants recruited patients from these clinics during this period. Additionally, any patient with Down's syndrome admitted to the wards within the study period was recruited into the study. We liaised with the records department to get this information on current admissions. Foot radiographs were performed at Plaza Imaging Centre, located at General Accident House, off Ngong Road.

## 3.4 STUDY PERIOD

This study was conducted during a three month period from March to May 2021.

### 3.5 STUDY POPULATION

These were children and young adults with Down's syndrome age 5 years - 21 years seen at KNH, consecutively recruited into the study.

#### 3.5.1 INCLUSION CRITERIA

1. Previously diagnosed child or young adult with Down's syndrome by karyotyping showing trisomy 21 or based on clinical phenotype.

2. Children and young adults with Down's syndrome ages 5 years to 21 years.

3. Parental consent.

#### 3.5.2 EXCLUSION CRITERIA

- Children mislabelled as Down's Syndrome without phenotypic features of Down's Syndrome or karyotype confirming Trisomy 21.
- Children and young adults with Down's syndrome who had had previous foot surgery, recent trauma to the foot or pre-existing foot pathology.

**SAMPLING METHOD**: Convenient sampling method was applied.

**SAMPLE SIZE CALCULATION:**

Based on the objective to determine the prevalence of Pes planus in children and young adults with Down's syndrome, Fischer's formula was used.

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1)+Z^2P(1-P)}$$

Where

$n'$ = sample size with finite population correction,

$N$ = size of the target population = 100

$Z$ = Z statistic for 95% level of confidence = 1.96

$P$ = Estimated prevalence of Pes planus in children and young adults with Down's syndrome =60%

$d$ = margin of error = 5%

The minimum sample size required to estimate prevalence within 5% margin of error was **79.**

For this study, the level of confidence of 95% was used and an error margin of ±5% considered as acceptable. Thus, A sample size of **N = 79** was used to achieve the required sufficient precision for the estimated prevalence of Pes planus in children and young adults with Down's syndrome.

Assumptions were as follows:

The estimated prevalence of Pes planus in children and young adults with Down's syndrome was 60% based on an observational study conducted by Concolino et al on early detection of podiatric anomalies on children with Down's syndrome(20). The total population of children with Down's syndrome seen at KNH from 2016-2018 was 100 based on data from the Health Information Department, KNH.

### 3.6 STUDY PROCEDURE

Children and young adults with Down's syndrome who met the inclusion criteria were enrolled in the study after obtaining consent from guardians and assent for older children who could comprehend depending on the level of intellectual ability.

This study was conducted by the principal investigator and research assistants. These research assistants were final year medical students who wished to assist in the study. The research assistants were there to assist in recording the questionnaires and taking anthropometric measurements. There was a one-day training prior to data collection so that they could familiarize themselves with the questionnaire, weighing scales, length and height board, calculation of BMI and plotting the value on the CDC growth chart. They were also trained on features of children and young adults with Down's syndrome although they would have already covered this in their curriculum.

The demographic data of each of the participants was recorded including age in years and gender. The diagnosis of Down's syndrome was confirmed either by previous karyotype test done or all physical features present namely upward slanting eyes, wide nasal bridge, low set ears, flat facial profile and palmar simian crease. A questionnaire was then administered to the parents or young adults to evaluate for presence of symptoms such as delayed walking and gait abnormalities.

Anthropometric measurements were taken and recorded: weight, height and BMI. Weight in kilograms was taken using a standardized beam balance or weighing scale. Height in centimetres was taken using a length/ height board (stadiometer). BMI was calculated from the weight in kilograms divided by height in square metres and plotted on a percentile graph to determine if the child is overweight or obese. See appendix for the graphs used. Obese children had a BMI > $95^{th}$ percentile while overweight children had a BMI >85- < $95^{th}$ percentile.

A physical exam was conducted on all participants starting with inspection of the foot with patient in weight bearing position and non-weight bearing position to evaluate for Pes planus

which is defined as loss of medial longitudinal arch of the foot on weight bearing. Both feet were assessed for flexibility and symmetry.

The participants found to have Pes planus had a lateral and AP foot x-ray done in weight bearing position. The x-rays were then assessed for Meary's angle, calcaneal inclination angle and talonavicular coverage angle.

**IMAGING PROCEDURES**

The imaging was done at Plaza Imaging Centre located at General Accident House, off Ngong Road. This was chosen because of its proximity to Kenyatta National Hospital (850m from KNH), convenience since we were able to book patients for imaging on specific days and had agreed upon subsidized costs of foot x-rays which were catered for by the principal investigator. However, for those already in the wards, the radiographs were done at KNH.

Ethical consideration of exposure to radiation was explained and consented for by the guardians. The foot x-rays were taken in weight bearing position from the lateral view and antero-posterior view by a trained radiographer. The study participants were asked to step on a platform one foot at a time then the images were taken from both views. The radiologist and principal investigator then assessed the x-ray films on hard copy for Meary's angle, calcaneal inclination angle and talonavicular coverage angle. The patient and their caregivers were given their radiograph films after assessment. Appropriate referrals to specialists were carried out for children who had not had screening for other complications that occur in children with Down's syndrome such as congenital heart defects or hypothyroidism.

### 3.7 VARIABLES

**Dependent:** Pes planus on observation and radiographic evaluation for all children with pes planus (symptomatic and asymptomatic)

**Independent:** Age, BMI, Symptoms (delayed ambulation and antalgic gait)

### 3.8 DATA COLLECTION TOOLS

Questionnaires were used to gather information on age, gender and anthropometry measurements (weight, height and BMI). In addition, history and physical examination findings were recorded. Plain radiographs of the foot in weight bearing position were done for all patients with pes planus.

### 3.9 QUALITY ASSURANCE PROCEDURES

The physical examination of all patients enrolled in the study was done by the principal investigator who is a senior resident in the Department of Orthopaedic surgery. The x-rays were taken at Plaza Imaging Centre located at General Accident House and were reviewed by a consultant radiologist and the principal investigator.

### 3.10 ETHICAL CONSIDERATIONS

**Permission:** Ethical approval to carry out this study was obtained from Kenyatta National Hospital and University of Nairobi Ethics and Research Committee as well as approval for other study documents.

**Risks:** There was exposure to radiation when conducting foot x-rays however the radiation dose was low and the benefits outweighed the risks. Pregnant patients and their parents and caregivers were NOT allowed to undergo imaging or enter the imaging room and disclosed this information beforehand.

**Benefits:** The study participants had a free musculoskeletal screening test done. Findings were communicated to the parents/guardians and treatment options discussed.

**Confidentiality:** Confidentiality was maintained at all stages including use of subject identification numbers on all documentation used. The information shared between the subject and investigator was confidential and was not shared with any third parties. The physical examinations and radiological investigations were conducted in an ethical manner ensuring privacy was always maintained and procedures explained, and consent obtained before any examination was done.

**Informed consent:** Informed consent was obtained from the caregivers following an explanation of the aims of the study. This process was voluntary and free from coercion. The parent/caregiver then signed the consent form.

**Assenting document:** This was provided for children and young adults who have mild intellectual disability and could comprehend what the study entails.

## COVID – 19 MITIGATION MEASURES

The primary researcher ensured that all members of his research team were trained on key aspects of COVID-19 infection prevention to mitigate the risk of infection. This included conducting online training to them with the help of World Health Organization (WHO) portal (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/training/online-training) and providing them with personal protective equipment as per WHO guidelines of risk stratification.

# CHAPTER FOUR

## 4.0 RESULTS

### 4.1: Introduction

### 4.2 Demographic Information

#### 4.2.1 Descriptive Statistics (Numerical)

The total number of children and young adults with Down's syndrome aged 5-21 years enrolled in the study were seventy-nine (79). The patients were aged between five (5) and twenty-one (21) years (Range 16 years). The mean age was 10.47 (95% Confidence Interval: 9.39 to 11.5). The patient with the lowest weight was fourteen (14) kilograms and the heaviest was eighty (80) kilograms. The mean weight was 39.91 (95%CI: 35.98 to 43.84). The shortest patient was eighty (80) centimetres while the tallest was one hundred and seventy-one (171) centimetres. The mean height was 129.14 (95%CI: 124.17 to 134.11). The minimum body mass index (BMI) was 14.7 and the maximum was 36.71. The mean BMI was 22.59 (95% CI: 21.59 to 23.59). Table 1 below displays the results.

**Table 1: Demographic Information 1**

| | N<br>Statistic | Minimum<br>Statistic | Maximum<br>Statistic | Mean<br>Statistic | Std.<br>Error | Std.<br>Deviation<br>Statistic |
|---|---|---|---|---|---|---|
| AGE OF PATIENT | 79 | 5 | 21 | 10.46 | 0.546 | 4.854 |

| | | | | | | |
|---|---|---|---|---|---|---|
| IN YEARS | | | | | | |
| WEIGHT(KGS) | 79 | 14 | 80 | 39.91 | 2.005 | 17.818 |
| HEIGHT(CMS) | 79 | 80 | 171 | 129.14 | 2.538 | 22.563 |
| B**ody** Mass Index | 79 | 14.7 | 36.71 | 22.5856 | 0.50987 | 4.53182 |

### 4.2.2 Descriptive Statistics (Categorical)

The majority of the patients were of the male gender (54.4%; n=43). The majority of the patients (89.9%; n=71) were diagnosed with Down's syndrome by physical exam. Thirty-nine (39) patients (49.4%) had delayed ambulation. Seventeen patients (16; 21.5%) had delayed ambulation for three years, ten patients (10; 12.7%) had delayed ambulation for four years, nine patients (9; 11.4%) had delayed ambulation for five years, one patient (1; 1.3%) had delayed ambulation for six years and two (2; 2.5 %) patients had delayed ambulation for seven years. The majority of the patients (46.8% n=37) were obese, ten patients (10, 12.7%) were overweight and thirty-two (32; 40.5%) were of normal weight. Only two (2; 2.5%) presented with an antalgic gait.

Table 2 below displays the distribution.

**Table 2: Demographic Data 2 (Categorical)**

| | | Frequency | Percent |
|---|---|---|---|
| Gender | Female | 36 | 45.6 |

| | | | |
|---|---|---|---|
| | Male | 43 | 54.4 |
| | Total | 79 | 100 |
| DIAGNOSIS OF DOWN'S SYNDROME: KARYOTYPE/ PHYSICAL EXAM | Physical Exam | 71 | 89.9 |
| | Karyotype | 8 | 10.1 |
| | Total | 79 | 100 |
| Weight level classification | Obese | 37 | 46.8 |
| | Overweight | 10 | 12.7 |
| | Normal | 32 | 40.5 |
| | Total | 79 | 100 |
| DELAYED AMBULATION | Yes | 39 | 49.4 |
| | No | 40 | 50.6 |
| | Total | 79 | 100 |
| Time-delayed ambulation in years | 0 | 40 | 50.6 |
| | 3 | 17 | 21.5 |
| | 4 | 10 | 12.7 |
| | 5 | 9 | 11.4 |

| | | | |
|---|---|---|---|
| | 6 | 1 | 1.3 |
| | 7 | 2 | 2.5 |
| | Total | 79 | 100 |
| ANTALGIC GAIT | Yes | 2 | 2.5 |
| | No | 77 | 97.5 |
| | Total | 79 | 100 |

## 4.3: THE PREVALENCE OF PES PLANUS IN CHILDREN AND YOUNG ADULTS AGED BETWEEN 5-21 YEARS WITH DOWN'S SYNDROME

### 4.3.1: Prevalence of Pes Planus in Children and young adults

The prevalence of flat foot was **63% (n=50) (95% CI: 51.69 to 73.86).**

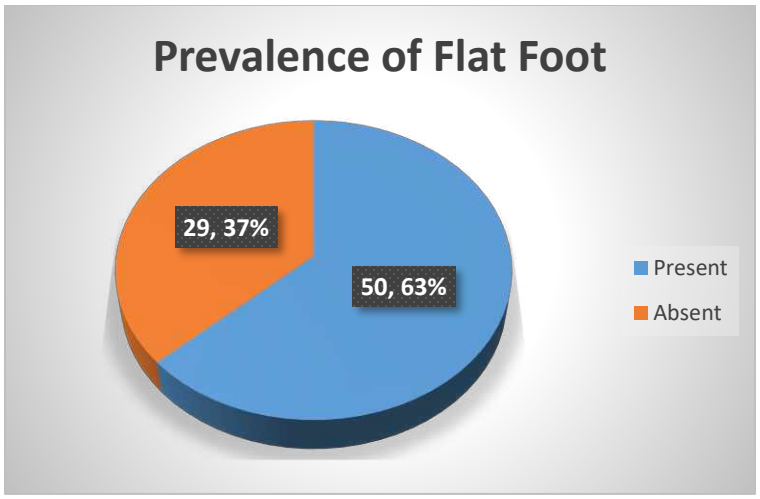


**Figure 8: Prevalence of Flat Foot**

### 4.3.2 Prevalence of Flat foot on the left limb in weight-bearing

The prevalence of left flat foot in weight-bearing was **56% (95% CI: 44 to 66.9).**

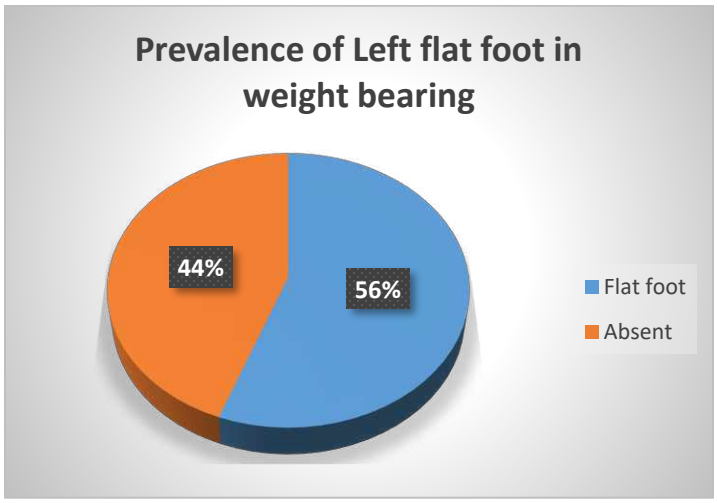


**Figure 9: Prevalence of Flat Foot on the Left in Weight Bearing**

### 4.3.3: Prevalence of Flat foot on the left limb in non-weight bearing

The prevalence of left flat foot in non-weight bearing was **33 %( 95%CI: 22.7 to 44.4%)**

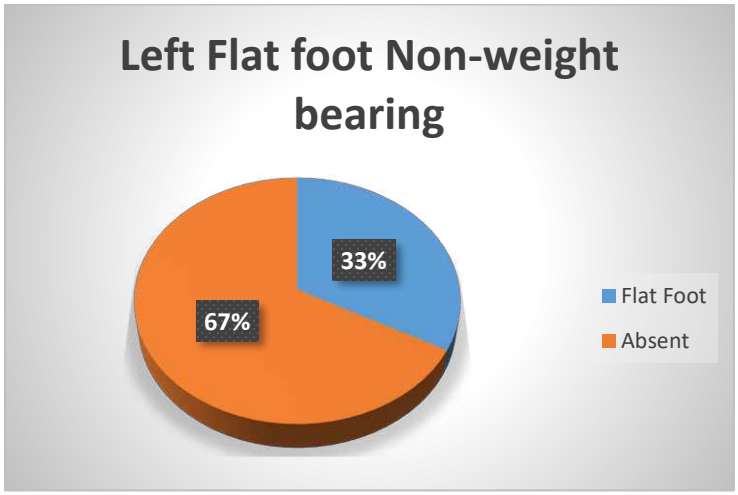

**Figure 10: Prevalence of Flat foot on the Left in Non-Weight Bearing**

### 4.3.4 Right flat foot in weight-bearing

The prevalence of right flat foot in weight-bearing was **52% (95% CI: 40.36 to 63.3).**

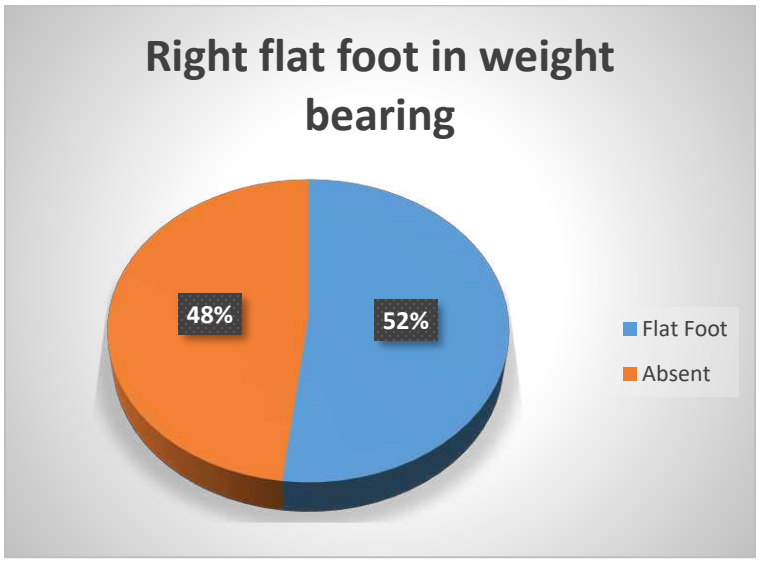


**Figure 11: Right Flat Foot in Weight Bearing**

### 4.3.5 Right flat foot in non-weight bearing

The prevalence of right flat foot in non-weight bearing was **24% (95%CI: 15.14 to 34.98).**

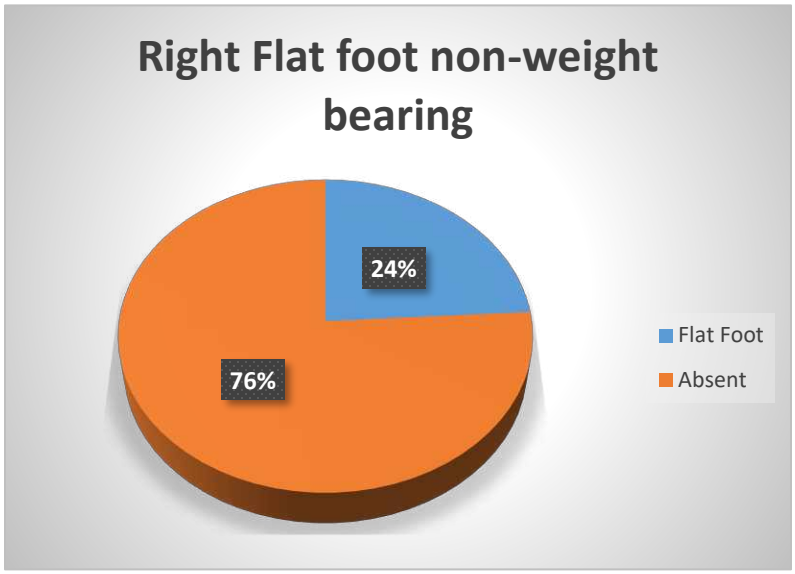


**Figure 12: Right Flat Foot in Non-Weight Bearing**

## 4.4 THE ASSOCIATION OF PES PLANUS (FLAT FOOT) WITH CHILD'S DEMOGRAPHIC CHARACTERISTICS

### 4.4.1: The Association of Pes Planus (Flat Foot) with Age of Child

There was no statistically significant association between the age of the child and the presence of Pes Planus (Spearman's rho correlation -0.059; p-value 0.606).

**Table 3: Association between Child's Age &Flat Foot**

| | | | PRESENCE OF FLAT FOOT | AGE OF PATIENT IN YEARS |
|---|---|---|---|---|
| | | | | -0.059 |
| Correlations Spearman's rho | PRESENCE OF FLAT FOOT | Correlation Coefficient | 1 | 0.606 |
| | | Sig. (2-tailed) | . | 79 |
| | | N | 79 | 1 |
| | AGE OF PATIENT IN YEARS | Correlation Coefficient | -0.059 | . |
| | | Sig. (2-tailed) | 0.606 | 79 |
| | | N | 79 | |

**Table 4: Relationship between Child's Age & Presence of Pes Planus**

| | | B | S.E. | Wald | df | Sig. | OR |
|---|---|---|---|---|---|---|---|
| **Step 1a** | **AGE** | **-0.027** | **0.049** | **0.294** | **1** | **0.588** | **0.974** |
| | **Constant** | **-0.268** | **0.558** | **0.231** | **1** | **0.631** | **0.765** |

### 4.4.2 Association between Child's Gender and Flat Foot

There was no statistically significant association between the child's gender and the presence of Pes Planus (Chi-square Value 0.135; df 1; P-Value 0.713).

**Table 5: Association between Child's Gender & Flat Foot**

| | | GENDER | | Total | Chi-square | Df | P-value |
|---|---|---|---|---|---|---|---|
| | | **Female** | **Male** | | | | |
| **PRESENCE OF FLAT FOOT** | **Present** | **22** | **28** | **50** | **0.135** | **1** | **0.713** |
| | **Absent** | **14** | **15** | **29** | | | |
| Total | | **36** | **43** | **79** | | | |

### 4.4.3 Association between child's BMI and Flat Foot

There was no significant association between the child's BMI and Pes Planus (Spearman's rho correlation 0.043, P-Value 0.709).

**Table 6: Association between Child's BMI & Flat Foot**

| | | | PRESENCE OF FLAT FOOT | Body Mass Index |
|---|---|---|---|---|
| **Correlations** **Spearman's rho** | PRESENCE OF FLAT FOOT | Correlation Coefficient | 1 | 0.043 |
| | | Sig. (2-tailed) | . | 0.709 |
| | | N | 79 | 79 |
| | Body Mass Index | Correlation Coefficient | 0.043 | 1 |
| | | Sig. (2-tailed) | 0.709 | . |
| | | N | 79 | 79 |

There was no statistically significant relationship between BMI and the presence of flat foot (OR: 1.002;P-Value-0.974).

**Table 7: Relationship between Child's BMI & Flat Foot**

| | | B | S.E. | Wald | df | Sig. | OR |
|---|---|---|---|---|---|---|---|
| **Step 1a** | **BMI** | **0.002** | **0.052** | **0.001** | **1** | **0.974** | **1.002** |
| | **Constant** | **-0.582** | **1.194** | **0.238** | **1** | **0.626** | **0.559** |

### 4.4.4: Association between child's Weight and Flat Foot

There was no statistically significant association between the weight level and Pes Planus (Chi-square 1.284; df: 2; P-Value 0.526).

**Table 8: Association between Child's Weight & Flat Foot**

| | | Weight level classification | | | Total | Chi-square | Df | P-value |
|---|---|---|---|---|---|---|---|---|
| | | Obese | Overweight | Normal | | | | |
| PRESENCE OF FLAT FOOT | Present | 21 | 7 | 22 | 50 | 1.284 | 2 | 0.526 |
| | Absent | 16 | 3 | 10 | 29 | | | |
| Total | | 37 | 10 | 32 | 79 | | | |

There was no statistically significant relationship between Child's weight and Flat foot (OR: 0.984; P-value 0.253).

**Table 9: Relationship between Child's Weight & Flat Foot**

| | | B | S.E. | Wald | df | Sig. | OR |
|---|---|---|---|---|---|---|---|
| Step 1a | **WEIGHT** | **-0.016** | **0.014** | **1.309** | **1** | **0.253** | **0.984** |
| | **Constant** | **0.073** | **0.58** | **0.016** | **1** | **0.899** | **1.076** |

## 4.5: RADIOLOGIC FEATURES OF PES PLANUS: MEARY'S ANGLE

Most(40.5%; n=32) of children had a normal Meary's angle. Twenty-five (25; 31.6%) had a Meary's angle of more than four degrees in the left foot x-rays. Twenty-two children (n=22; 27.8%) had Meary's angle more than 4 degrees in the right foot x-rays.

**Table 10: Meary's Angle**

| | Frequency | Per cent(%) |
|---|---|---|
| Right **foot** More than 4 | 22 | 27.8 |
| Left **foot** More than 4 | 25 | 31.6 |
| Normal | 32 | 40.5 |
| Total | 79 | 100 |

## 4.6 CALCANEAL INCLINATION ANGLE

Twenty-one patients (n=21; 26.6%) had calcaneal inclination angle less than 18 degrees on the right foot x-rays. Thirty-two patients (n=32; 40.5%) had a normal calcaneal angle. Twenty-six (n=26; 32.9%) children had a calcaneal angle of less than eighteen degrees on the left foot x-rays.

**Table 11: Calcaneal Inclination Angle**

| | Frequency | Per cent |
|---|---|---|
| Right foot Less than 18 | **21** | **26.6** |
| Left foot Less than 18 | **26** | **32.9** |
| Normal | **32** | **40.5** |
| Total | **79** | **100** |

## 4.7 TALONAVICULAR COVERAGE ANGLE

A majority (n=30; 38%) had a normal talonavicular coverage angle. Children with a talonavicular angle more than seven degrees on the left foot x-rays were nineteen (n=28; 35.4%). Twenty-one (n=21; 26.6 %) had a talonavicular angle of more than seven degrees on right foot x-rays

**Table 12: Talonavicular Coverage Angle**

| | Frequency | Percent |
|---|---|---|
| Right foot More than 7 | **21** | **26.6** |
| Left foot More than 7 | **28** | **35.4** |
| Normal | **30** | **38** |
| Total | **79** | **100** |

Additional radiological findings included: Hallux valgus (n=16; 20.2%), Tarsal coalition (n=5; 6.3%), Brachymetatarsia (n=2; 2.5%) and Syndactyly (n=1; 1.3%).

The figure below shows a right foot x-ray of one of the participants showing, calcaneal inclination angle = 11°(pes planus), Meary's angle = 18º (pes planus) and a talonavicular coverage= 3° (normal). Additionally, 1st metatarsophalangeal angle = 19° (Hallux valgus).

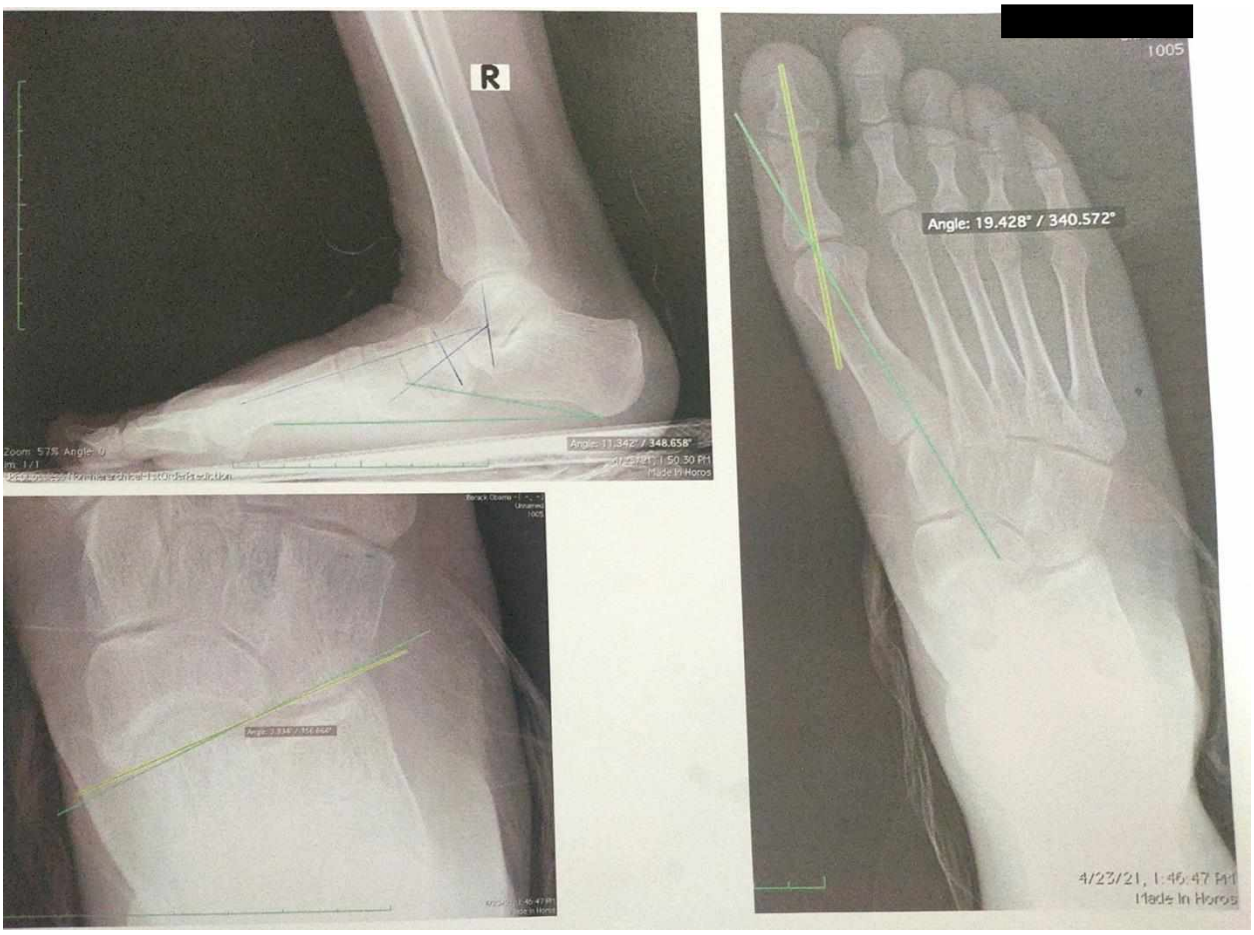


**Figure 13: X-ray showing Reduced Calcaneal Inclination Angle (11 degrees), Meary's angle (18 degrees) and Talonavicular coverage angle (3 degrees) consistent with Pes Planus. 1st Metatarsal angle (19 degrees) consistent with Hallux Valgus.**

# CHAPTER FIVE

## 5.1 DISCUSSION

The prevalence of pes planus in children and young adults aged between 5- 21 years with Down Syndrome from this study was **63% (n=50) (95% CI: 51.69 to 73.86**). A case-control study conducted by Concolino et al which compared 50 children with Down's Syndrome aged 4-10 years to 100 healthy children found that the prevalence of flat foot was 60% compared to 10% in normal children (20). According to Perotti et al (10) in his observational study on foot and ankle deformities in children with Down's Syndrome, he found that the prevalence of flat foot in children under the age of 10 years was 58%, 59% in children between 10 and 13.9 years and 57% in children older than 14 years(10). Foley and Killeen in their study on musculoskeletal anomalies in children with Down Syndrome found that the prevalence of pes planus in children ages 0-21 years was 91 %(27).

The prevalence of flat foot which presents in weight-bearing position was 56% (95% CI: 44 to 66.9) of the left feet examined and 52% (95% CI: 40.36 to 63.3) of the right feet examined. The flat foot which is present in non-weight bearing position was 33 %( 95%CI: 22.7 to 44.4%) of the left feet examined and 24% (95%CI: 15.14 to 34.98) of the right feet examined. Flat foot of the flexible type has been shown to improve with age in normal children, but this has not been demonstrated in children with Down's Syndrome as seen in Perotti's study which demonstrated radiographic features of flat foot in weight-bearing position in children older than 10 years(10).

Seventy-nine (79) children and young adults aged 5-21years were enrolled on this study. The majority of the patients were diagnosed to have Down's syndrome based on physical exam (89.9% n=71) while only 8 (10.1%) had had karyotyping done. The mean age in years was 10.47

(95% Confidence Interval: 9.39 to 11.5). Concolino's study had a sample population of 50 children with Down's Syndrome aged 4- 10 years(20). Perotti's retrospective study looked at 581 children with Down's Syndrome seen between 2004 and 2015(10). Foley and Killeen's observational study conducted over 18 months at a musculoskeletal assessment clinic conducted by a paediatrician had 503 children with DS ages 0-21 years with a median age of 8.1 years (0.6-19.2 years). There was no statistically significant association between the age of the child and the presence of Pes Planus (Spearman's rho correlation -0.059; p-value 0.606) (27). Perotti's study also found no significant association between radiographic measurements of pes planus and different age groups (less than 10 years, 10-13.9 years and >14 years)(10).

Of the 79 study participants, 43 (54.4%) were male while 36 (45.6%) were female with a male to female ratio of 1.19:1. There were 56% of males and 44% of females in Foley and Killeen's observational study(27). Generally, the male to female ratio in children with Down's syndrome is 1.15: 1. There was no statistically significant association between the child's gender and the presence of Pes Planus (Chi-square Value 0.135; df 1; P-Value 0.713).

The range of body mass index (BMI) was 14.7 - 36.71 with an average BMI of 22.59 (95% CI: 21.59 to 23.59). In children and young adults with Down's Syndrome and increased BMI, the incidence of foot deformities is high(10). There was no significant association between the child's BMI and Pes Planus (Spearman's rho correlation 0.043, P-Value 0.709). Similarly, Perotti et al found there was no statistically significant association between BMI and radiographic measurement angles of pes planus(10).

The majority of the patients (46.8% n=37) were obese, ten patients (10, 12.7%) were overweight and thirty-two (32; 40.5%) were of normal weight. Obesity is common in children and young

adults with Down's syndrome due to excessive weight gain resulting from a genetic condition, metabolic and hormonal disorders, lack of exercise and poor dietary habits (28). There was no statistically significant association between the weight level and Pes Planus (Chi-square 1.284; df: 2; P-Value 0.526).

Thirty-nine (39) patients (49.4%) had delayed ambulation with a median age of walking of 3 years (3-7years). Similarly, Foley and Killeen's study noted that children with Down's syndrome had delays in ambulation with the median age of walking found to be 23 months (13-48 months)(27). Antalgic gait was present in only 2 participants (2.5%).

All 79 participants had foot radiographs done in a weight-bearing position. In Perotti's study, radiographic evaluation of foot and ankle showed a higher prevalence of deformities than clinical examination but radiographic evaluation was done on those with flat foot. However, from this study, pes planus was noted more on clinical examination than radiographic evaluation(10) as all the children were evaluated radiographically.

Meary's angle of more than 4 degrees indicates pes planus was noted more on the left foot x-rays (31.6%; n=25) compared to the right foot x-rays (n=22; 27.8%). Normal meary's angle of zero (0) degrees was noted in 32 (40.5%) patients.

The calcaneal inclination angle of less than 18 degrees which indicates pes planus was present in 26 (32.9 %) patients on left foot x-rays compared to 21 (26.6%) on right foot x-rays. Normal calcaneal inclination angle was present in 32 (40.5%) patients.

Talonavicular coverage angle of more than 7 degrees indicates pes planus and was found in 28 (35.4%) patients on the left foot compared to 21(26.6%) patients with an angle more than 7

degrees on the right foot. Normal talonavicular coverage which is less than 7 degrees was found in 30 (38%) patients.

## 5.2 CONCLUSION AND RECOMMENDATIONS

The prevalence of pes planus in children and young adults aged between 5- 21 years with Down syndrome from this study was 63%. This translates to 6 out of 10 children with Down's syndrome having a flat foot. The majority of the patients had flexible flat foot which was more on the left foot compared to the right foot both clinically and radiologically. The prevalence of pes planus was higher on the clinical exam compared to foot x-rays. There was no significant association noted between age, weight or BMI with pes planus. Obesity is common in children with Down's syndrome. Delayed ambulation occurs frequently in this population with a median age of walking of 3 years from this study. Foot x-rays are useful for making a diagnosis of Pes planus by taking measurements i.e. Meary's angle, Calcaneal inclination angle and Talonavicular coverage angle.

Routine screening of musculoskeletal disorders particularly foot disorders in children and young adults with Down's syndrome is recommended since the prevalence of flat foot in this population is high as noted from the study.

## 5.3 STUDY STRENGTHS

This study highlighted the prevalence and associated factors of pes planus in children and young adults with Down's syndrome aged 5-21 years. This was a follow up to Munyao's study in KNH in 2016 among children with Down's Syndrome that were assessed for age-appropriate screening of children with Down's Syndrome. He found that there were missing gaps in their screening for

complications. The study participants were offered a free musculoskeletal screening which is recommended for this population(12).

### 5.4 STUDY LIMITATIONS

The cost of this study was high because the principal investigator catered for the cost of the radiological investigations. Additionally, the logistics involved in organizing all patients in one place to collect the data were costly.

There may have been recall bias/ reporting bias in reporting of symptoms such as delay in ambulation and antalgic gait.

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# APPENDICES

**APPENDIX 1: CONSENT FORM FOR PARTICIPATION IN THE STUDY**

**STUDY TITLE: PREVALENCE OF PES PLANUS IN CHILDREN AND YOUNG ADULTS WITH DOWN'S SYNDROME AT KENYATTA NATIONAL HOSPITAL**

**Patient's Study Identification Number: _____**

**Date: _____**


**Investigator:** **Dr Brian. Momanyi**

Orthopaedic Resident, University of Nairobi

Tel no: 0705 951712

**Supervisors:** **Prof. J.A.O Mulimba**

Professor Department of Orthopaedic Surgery,

University of Nairobi

Tel no: 0722 711 217

**Dr John Kingori**

Lecturer, Department of Orthopaedic Surgery

University of Nairobi

Tel 0725 979 524

**Investigator's Statement**

I am a postgraduate student at the University of Nairobi pursuing a Master of Medicine degree in Orthopaedic Surgery. As part of fulfilment for the above degree, I wish to conduct a study on the prevalence of pes planus in children and young adults with Down's Syndrome.

**Study Background**

Pes planus, also known as flat foot, is a physiologic variant consisting of a decrease in the medial longitudinal arch and a valgus hindfoot and forefoot abduction with weight-bearing. Pes planus is a common foot disorder in patients with Down's syndrome and is associated with significant morbidity. If left untreated, it can result in arthritis and delay in ambulation.

**Broad Objective**

This study aims to assess the prevalence of Pes planus in children and young adults with Down's syndrome aged 5- 21 years seen at Kenyatta National Hospital.

**Voluntariness of Participation**

Participation is entirely voluntary. There will be no financial rewards to you for participating in the study. One is free to participate or withdraw from the study at any point. Refusal to participate will not compromise your child's care in any way.

**Confidentiality**

Confidentiality will be maintained at all stages. All evaluation forms, reports and other records used will be identified only by the Subject Identification Number (SIN) to maintain subject confidentiality. Clinical information will not be released without the written permission of the subject. The physical examinations and radiological investigations will be conducted in an ethical manner ensuring privacy are always maintained and procedures explained, and consent obtained before any examination is done.

**Benefits**

Your participation in this study will help me determine the number of children with Down's syndrome who have Pes planus or flat foot. The results of this study will help create awareness among health workers in this facility and improve the management of these special children. The study will help caregivers of children with Down's Syndrome understand how better to care for their children and the importance of early screening to prevent the long-term complications of Pes planus.

**Risks**

There will be radiation exposure to children undergoing foot x rays however the radiation dose is low to cause any harm.

**Right of Withdrawal**

One has a right to withdraw from the study at any point. There will be no penalties.

**Problems or Questions:**

If you ever have any questions about the study or about the use of the results you can contact the principal investigator, Dr Brian Momanyi by calling 0705 951 712

If you have any questions regarding your rights as a research participant, you can contact the Kenyatta National Hospital Ethics and Research Committee (KNH- ESRC) by calling 2726300 Ext. 44355.

**Consent Form: Participant's Statement:**

I _____having received adequate information regarding the study research, risks, benefits hereby AGREE / DISAGREE (Cross out as appropriate) to participate in the study with my child. I understand that our participation is fully voluntary and that I am free to withdraw at any time. I have been given adequate opportunity to ask questions and seek clarification on the study and these have been addressed satisfactorily.

Parents Signature: _____ Date_____

I _____declare that I have adequately explained to the above participant, the study procedure, risks, and benefits and given him /her time to ask questions and seek clarification regarding the study. I have answered all the questions raised to the best of my ability.

Interviewers Signature_____ Date_____

**APPENDIX 1 (KISWAHILI)**

**IDHINI YA KUSHIRIKISHWA KATIKA UTAFITI**

**Kauli ya Mchunguzi**

Mimi ni mwanafunzi wa uzamili katika Chuo Kikuu cha Nairobi nikiendelea na masomo ya shahada ya Udaktari katika Upasuaji wa Mifupa. Kama sehemu ya utimilifu kwa kiwango cha hapo juu, ningependa kufanya utafiti juu ya kuenea kwa "pes planus" ama mguu tambarare kwa watoto na vijana wazima wenye Down's Syndrome.

**Historia ya Kusoma**

"Pes planus" ni aina ya shida ya miguu inayojumuisha kupungua kwa upinde wa urefu wa kati. Pes planus ni shida ya kawaida ya miguu kwa wagonjwa walio na ugonjwa wa Down's Syndrome. Ikiachwa bila kutibiwa, inaweza kusababisha ugonjwa wa "arthritis" na kuchelewesha kutembea.

**Lengo Pana**

Malengo ya utafiti huu ni kutathmini kuenea kwa shida ya "Pes planus" ama mguu tambarare kwa watoto na vijana walio na Down's Syndrome wenye umri wa miaka 5- 21 inayoonekana katika Hospitali ya Kitaifa ya Kenyatta.

**Kujitolea Kushiriki**

Kushiriki ni hiari kabisa. Hakutakuwa na tuzo za kifedha kwako kwa kushiriki katika utafiti. Mtu yuko huru kushiriki au kujiondoa kwenye utafiti wakati wowote. Kukataa kushiriki hakutapunguza utunzaji wa mtoto wako kwa njia yoyote.

**Usiri**

Usiri utahifadhiwa katika hatua zote. Fomu zote za tathmini, ripoti na rekodi zingine zilizotumiwa zitatambuliwa tu na Nambari ya Kitambulisho cha Somo (SIN) kudumisha usiri wa somo. Maelezo ya kliniki hayatatolewa bila ruhusa ya maandishi ya mhusika. Uchunguzi wa mwili na uchunguzi wa eksirei utafanywa kwa njia ya kimaadili kuhakikisha faragha inadumishwa kila wakati na taratibu zinaelezewa, na idhini iliyopatikana kabla ya uchunguzi wowote kufanywa.

**Faida**

Ushiriki wako katika utafiti huu utanisaidia kujua idadi ya watoto walio na ugonjwa wa Down ambao wanao Pes planus au mguu tambarare. Matokeo ya utafiti huu yatasaidia kujenga uelewa kati ya wafanyikazi wa afya katika kituo hiki na kuboresha usimamizi wa watoto hawa maalum. Utafiti huo utasaidia walezi wa watoto walio na Ugonjwa wa Down's Syndrome kuelewa jinsi bora ya kuwajali watoto wao na umuhimu wa uchunguzi wa mapema ili kuzuia shida za muda mrefu za Pes planus.

**Hatari**

Kutakuwa na mfiduo wa mionzi kwa watoto wanaopitia xray ya miguu lakini itakuwa chini bila ya kusababisha madhara yoyote.

**Haki ya Kujiondoa**

Mtu ana haki ya kujiondoa kutoka kwa utafiti wakati wowote. Hakutakuwa na adhabu.

**Shida au Maswali:**

Ikiwa una maswali yoyote kuhusu utafiti au kuhusu matumizi ya matokeo unaweza kuwasiliana na mpelelezi mkuu, Dk. Brian Momanyi kwa kupiga simu 0705 951 712

Ikiwa una maswali yoyote kuhusu haki zako kama mshiriki wa utafiti unaweza kuwasiliana na Kamati ya Maadili ya Hospitali ya Kitaifa ya Kenyatta na Kamati ya Utafiti (KNH- ESRC) kwa kupiga simu kwa 2726300 Ext. 44355.

**Fomu ya Idhini: Taarifa ya Mshiriki:**

Mimi _____nimepokea habari za kutosha kuhusu utafiti, faida hapa NAKUBALIANA / SIKUBALI (Toka kadiri inavyofaa) kushiriki kwenye utafiti na mtoto wangu. Ninaelewa kuwa ushiriki wetu ni wa hiari kabisa na kwamba niko huru kujiondoa wakati wowote. Nimepewa nafasi ya kutosha kuuliza maswali na kutafuta ufafanuzi juu ya utafiti na haya yameshughulikiwa kwa kuridhisha.

Sahihi ya Wazazi: _____ Tarehe_____

Nimeelezea vya kutosha kwa mshiriki hapo juu, utaratibu wa utafiti, hatari, na faida na kumpa wakati wake wa kuuliza maswali na kutafuta ufafanuzi kuhusu utafiti huo. Nimejibu maswali yote yaliyoulizwa kwa uwezo wangu wote.

Sahihi ya mhojiwa_____ Tarehe_____

**APPENDIX 2: ASSENTING FORM**

**ASSENTING DOCUMENT: To be filled by children and young adults with mild intellectual disability and good comprehension.**

**STUDY TITLE: PREVALENCE OF PES PLANUS IN CHILDREN AND YOUNG ADULTS WITH DOWN'S SYNDROME AT KENYATTA NATIONAL HOSPITAL**

I am doing a study to understand some of the health problems that you may be facing as a child or young adult with Down's syndrome. I would like to ask you and your parent some questions and then do a physical examination and perform an X-ray if necessary.

There is no right or wrong answer.

All answers/responses you give will be private and confidential.

You can ask questions about this study and if you wish not to continue you can ask us to stop.

If you don't want to be in the study, don't sign this paper. No one will be upset with you if you don't sign.

If you sign this paper it means you have read and understood the above information and agree to participate in this study.

Your signature_____Date_____

Signature of person obtaining assent_____Date_____

Printed Name of Person Obtaining assent_____

**APPENDIX 2: (KISWAHILI)**

**FOMU YA "ASSENT": Kujazwa na watoto na vijana wenye Down's Syndrome na ulemavu mdogo wa kiakili na ufahamu mzuri.**

**KIWANGO CHA "PES PLANUS" AMA MGUU TAMBARARE ULIO KWA WATOTO NA VIJANA WENYE DOWN'S SYNDROME KATIKA HOSPITALI YA TAIFA YA KENYATTA**

Ninafanya utafiti kuelewa shida zingine za kiafya ambazo unaweza kuwa unakabiliwa nazo kama mtoto au mtu mzima mchanga aliye na ugonjwa wa Down's Syndrome. Ningependa kukuuliza wewe na mzazi wako maswali kadhaa kisha ufanye uchunguzi wa mwili na ufanye X-ray ikiwa ni lazima.

Hakuna jibu sahihi au sahihi.

Majibu / majibu yote utakayotoa yatakuwa ya faragha na ya siri.

Unaweza kuuliza maswali juu ya utafiti huu na ikiwa hutaki kuendelea unaweza kutuuliza tuache.

Ikiwa hautaki kuwa kwenye utafiti, usisaini karatasi hii. Hakuna mtu atakayekukasirikia ikiwa hautasaini.

Ikiwa utasaini karatasi hii inamaanisha kuwa umesoma na kuelewa habari iliyo hapo juu na unakubali kushiriki katika utafiti huu.

Saini yako_____ Tarehe_____

Saini ya mtu anayepata idhini _____Tarehe _____

Jina la Mtu aliyechapishwa Kupata idhini_____

**APPENDIX 3: QUESTIONNAIRE**

**STUDY TITLE: PREVALENCE OF PES PLANUS IN CHILDREN AND YOUNG ADULTS WITH DOWN'S SYNDROME AT KENYATTA NATIONAL HOSPITAL**

- Date of birth_____ Age of patient:_____
- Gender: Male Female
- Diagnosis of Down's Syndrome:
    - Previous karyotyping/genetic test done Y/N
    - Physical exam: Features noted (upward slanting eyes, wide nasal bridge, low set ears, flat facial profile and palmar simian crease) Y/N
- Anthropometry measurements
    - Weight (Kg) _____
    - Height (cm) _____
    - BMI (Wt/Ht($m^2$)) _____
    - Obesity: BMI> $95^{th}$ centile (based on graph) Y/N ____
    - Overweight: BMI > $85^{th}$ centile < $95^{th}$ centile (based on graph) Y/N ____
- Presence of symptoms Y/N_____
- If yes, any:
    - Delayed ambulation > 28 months Y/N _____

- Antalgic gait Y/N_____

***For those who are symptomatic, kindly order for a lateral and AP foot Xray in weight bearing position**

- On Inspection of foot :

| **Variable** | **Left foot** | **Right foot** |
|---|---|---|
| **Weight bearing**<br>**Non weight bearing**<br>**Flexible flat foot** | | |
| **Rigid flat foot**<br>**Symmetry of both feet** | | |

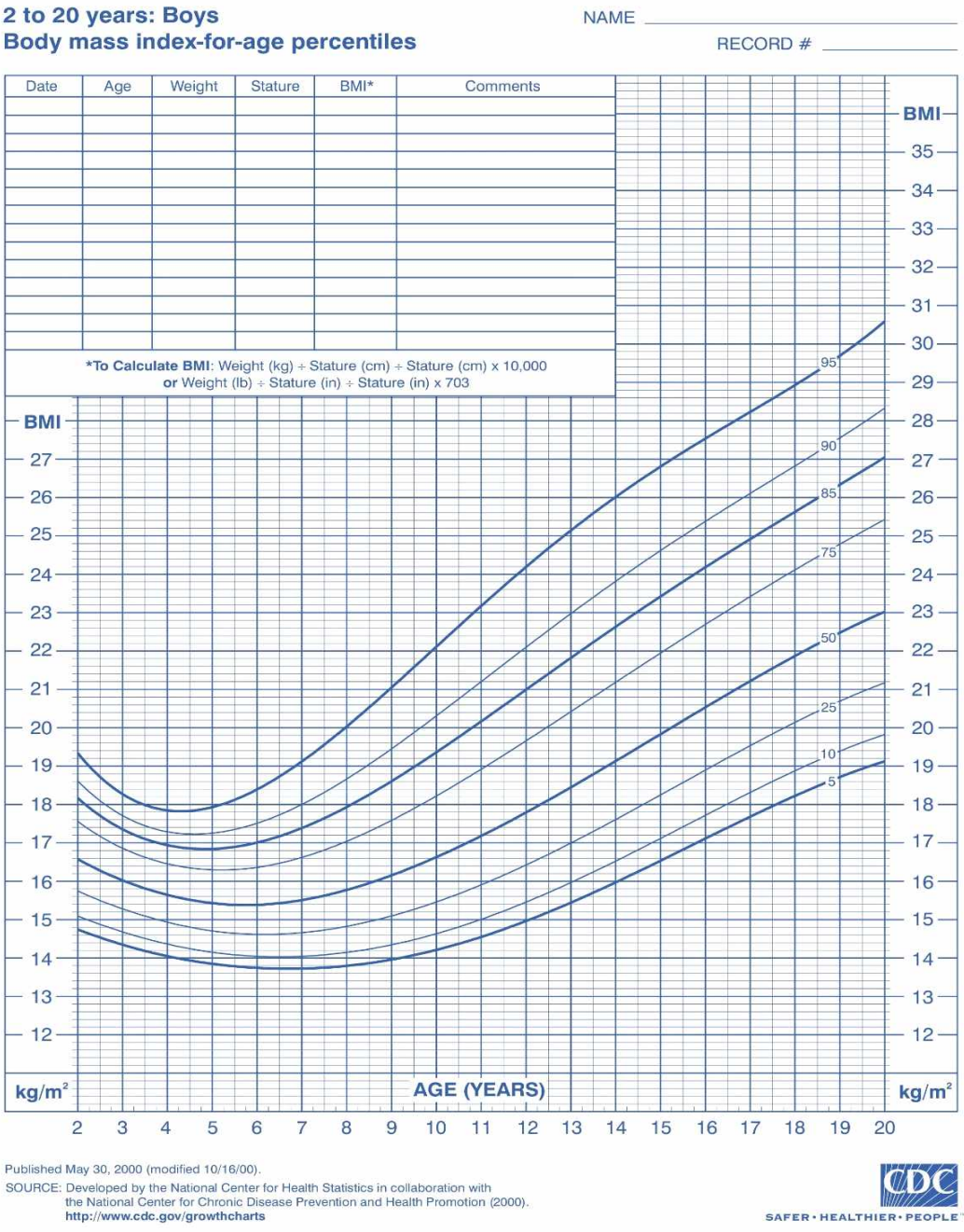
- On palpation of the foot

| **Variable**<br>**Posterior Tibial tendon** | **Left foot** | **Right foot** |
|---|---|---|
| **Plantar fascia**<br>**Range of motion** | | |
| **Jack Test** | | |
| **Single toe raise (muscle strength assessment)**<br>**Foot inversion against resistance (posterior tibial** | | |

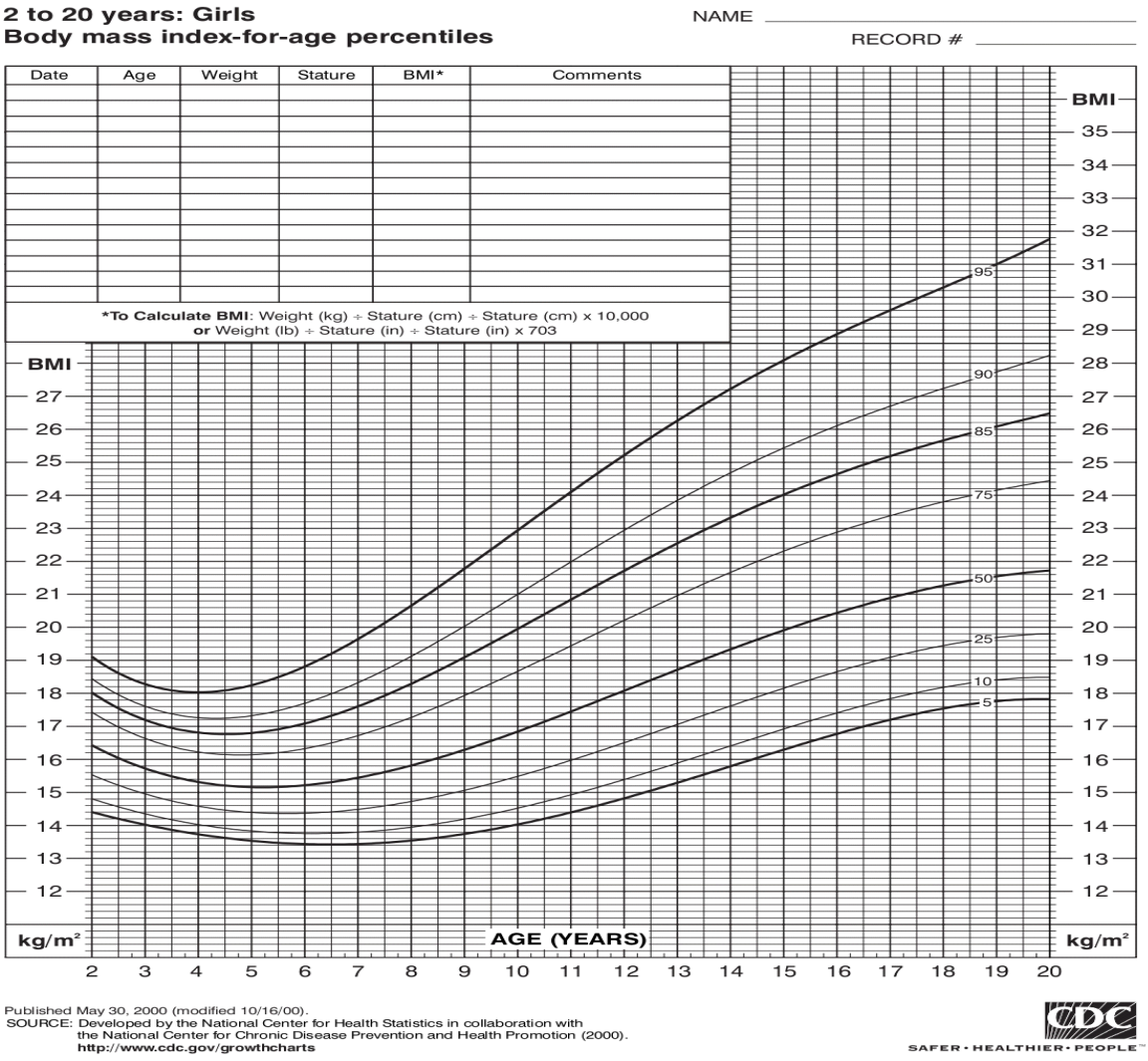
| | | |
|---|---|---|
| **tendon muscle strength)** | | |

- Gait assessment:
    - Normal gait Y/N
    - Antalgic gait Y/N
- For those with pes planus (symptomatic or asymptomatic) and a lateral and AP Xray has been done:
    - Meary's angle > 4º Y/N ___
    - Calcaneal inclination angle < 18 º Y/N
    - Talonavicular coverage angle >7 º Y/ N
    - Other coincidental findings Y/N
    - If yes which ones?

## APPENDIX 4: BMI FOR AGE PERCENTILE GRAPH FOR BOYS 2-20 YEARS



## BMI FOR AGE PERCENTILE GRAPH FOR GIRLS 2-20 YEARS



# PREVALENCE AND ASSOCIATED FACTORS OF PES PLANUS IN CHILDREN AND YOUNG ADULTS WITH DOWN'S SYNDROME AT KENYATTA NATIONAL HOSPITAL

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