ADDIS ABABA UNIVERSITY
COLLEGE OF HEALTH SCIENCES
DEPARTMENT OF ANATOMY

ASSOCIATION BETWEEN FOOT TYPE AND PODOCONIOSIS: COMPARATIVE CROSS-SECTIONAL STUDY, NORTH WEST, ETHIOPIA, 2018/19

BY: YIKEBER ARGACHEW (BSC, MSC CANDIDATE IN ANATOMY)

A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY FOR THE PARTIAL FULFILLMENT OF REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN ANATOMY.

ADVISOR: DR. GIRMA SEYOUM (PHD, ASSOCIATE PROFESSOR, AND DEPARTMENT HEAD)
CO-ADVISOR: DR. MUSTEFA ENDRIS (RADIOLOGIST AND DEPARTMENT HEAD)

JUNUARY 2020
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DECLARATION

I, THE UNDERSIGNED, DECLARED THAT THIS IS MY WORK AND THAT ALL SOURCES OF MATERIALS USED FOR THIS THESIS HAS DULY ACKNOWLEDGED.

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ABBREVATIONS AND ACRONYMS

AIDS – Acquired Immune Deficiency Syndrome

BMI –Body Mass Index

FL – Feiss Line

FMOH – Federal Ministryof Health

FPI – Foot Posture Index

HIV –Human Immune Virus

IOCC – International Orthodox Christian Charity

LAA – Longitudinal Arch Angle

MFTPA –Mossy Foot Treatment and Prevention Association

MLA – Medial Longitudinal Arch

ND – Navicular Drop

NH – Navicular Height

NTD – Neglected Tropical Diseases

SD –Standard Deviation

WHO – World Health Organization

Abstract

Background: Podoconiosis is neglected tropical diseases of foot; that affects barefooted subsistence farmers who have long term exposure for volcanic red soils. In earlier studies the diseases is assumed to be caused by genetic –environment interaction. The fact that the diseases are multi factorial in origin and not all barefooted individuals develop podoconiosis initiates the researcher to investigate which type of foot is more liable to develop podoconiosis.

Methodology: Comparative cross-sectional study design was conducted in Gojjam North west Ethiopia using standard clinical (FPI-6) measurements for control groups and digital radiographic (angular) measurements for cases to determine foot type. Univarate, bivarate and multivariate analysis was used.

Result: A total of 144 households with 144 members aged 18 years and above were included in the study. Almost all patients (99.0%) were in the age group 15-64 (the age group that includes economically active individuals in Ethiopia), did not read or write (65.0%), and were farmers (87.0%). Those who are illiterate, un married were more affected by podoconiosis (AOR = 3.378, p=0.079 and AOR = 8.664, p = 0.027). The average monthly income is the other finding which is associated with podoconiosis development (AOR =0.999, p< 0.001). Individuals who were shoes early in their life are less likely to develop podoconiosis (1.075, p = 0.018). The population with low and high arched are more likely to develop podoconiosis (AOR = 2.096 and AOR=15.383) respectively.

Discussion: In our study low and high arched community members who are above age eighteen are more likely to develop podoconiosis. This may be the low arched foot exposes individuals in more surface area to volume ratio for the ground so that the chance of the silica to penetrate the foot will be increased where as for those who are high arched individuals the plantar pressure between the foot and the ground is high than other foot types that may again give the opportunity for red silica to penetrate the skin of the foot.

Conclusion and recommendation: The study winds up with individuals who have low arched foot are more affected with podoconiosis than other foot types. The findings of the study also reassure podoconiosis affects more the poor and illiterate population than the rich and literate population. For this the researcher suggests large scale combination of foot parameters and genetics should be done for developing effective management of podoconiosis

INTRODUCTION

1. Background

1.1 Overview of podoconiosis

Podoconiosis is endemic non-filarial elephantiasis which is a non-infectious geochemical disease arising in barefoot subsistence farmers who are in long-term contact with irritant red clay soil of volcanic origins[1-3]. Podoconiosis is prevalent among subsistence barefoot farmers that live and work in these areas[2, 3]. It has been identified as an important neglected tropical disease (NTD) in East Africa, South America and Asia [4-9] ,and is estimated to affect 1 million people in Ethiopia alone[10]. This neglected tropical disease is characterized by bilateral swelling of the lower legs with mossy and nodular changes to the skin, and causes considerable disability[2].

Podoconiosis is a multifactorial disease with evidence of genetic susceptibility and environmental exposure[11].Although the etiology is not fully understood, current evidence suggests genetic susceptibilityand the role of mineral particles from irritant volcanic soils supposed to cause podoconiosis[12].The disease only affects some barefoot individuals – not all exposed individuals develop podoconiosis.

Podoconiosis follows a chronic course causing progressively increasing disability with continued exposure to irritant soils. It results in bilateral progressive chronic swelling of the lower legs, usually limited below the level of the knees. The pathogenesis of the disease has not yet been investigated in depth, but it is believed to be caused by fine particles in the soil that penetrate the skin and induce an inflammatory reaction in the lymphatic system [13]. However, early stage disease can easily be treated by foot hygiene, bandaging and shoes.

Podoconiosis is classified into five stages where the first stage swelling is limited to below the ankle and is reversible overnight. The second stage swelling is not reversible, and when bumps and knobs are present they remain below the level of the ankle. In the third stage of the disease, bumps and knobs are found above the level of the ankle. The fourth stage entails above knee swelling whereas the fifth stage involves joint fixation as a result of surrounding soft tissue overgrowth [13].

Figure 1 : Podoconiosis at different stages in four approximately 50 year old women, from western Ethiopia, (Picture by Jessica Shortall).

Podoconiosis can be prevented, early forms of the disease can be treated, and disease progression can be controlled with simple but effective measures such as washing feet with soap and water on a regular basis and wearing protective shoes consistently[14]. Podoconiosis has recently been included in the World Health Organization's Neglected Tropical Diseases (NTDs) list[15].

Areas of high prevalence of podoconiosis have been documented in tropical Africa, Central America and north India [3]. Of affected countries, Ethiopia appears to have the highest number of people with podoconiosis [2], with 11 million peopleat risk through exposure to irritant soil, and an estimated 1 million people affected countrywide (4).In Ethiopia, prevalence estimates range from 2.8 to 7.4% in endemic areas [4, 5, 16-21].

To date, podoconiosis interventions are only found in a few endemic areas [22]and the disease is poorly understood by many of Ethiopia's healthcare professionals[23].

Podoconiosis is one of the neglected tropical diseases (NTDs), a group of conditions found in[13]tropical areas and related to poverty. NTDs affect approximately one billion people worldwide[24]. Similar to other NTDs[25] , podoconiosis causes chronic disability and morbidity rather than death[13]. In addition to the high burden of disability, the social, economic and psychological sequelae are significant[22, 26, 27]. These include isolation, exclusion from community events,[28] and barriers to employment, education and marriage[22].These are key activities for both social and economic well-being. The economic costs of the condition are also high, with direct treatment costs equivalent to US$143 per patient per year, and total costs estimated to be US$16 million per annum in one zone in southern Ethiopia[22]. In addition, the physical challenges of the condition contribute to large productivity losses[22]. Podoconiosis is often poorly understood and affected individuals face severe stigma[27, 29]. This is similar to other diseases that cause deformity, such as lymphatic filariasis and leprosy,[24, 29] and as with these conditions, stigma is likely to compound the psychosocial effects of the condition.

1.2 Overview of foot types

Foot arches are the result of the successive evolution of basic human activities such as walking [30-32]. Among the vertebrates, only humans have foot arches [33].

The foot is one of the most important interaction parts of the body with the ground in upright posture. The structure of the foot is critical to affect the load absorbed by the bones in the foot and the force transferred to proximal components of lower extremity when performing exercise with weight bearing on foot[34]. Medial longitudinal arch is the largest arch of the foot and the most important arch of the foot from a clinical point of view. The bony shape, the ligaments of the foot, and the muscular tones all play an important role in supporting the arches [35].

Based on the structure of the medial longitudinal arch, three types of the foot have been proposed: 1. normally aligned or normal foot, 2. low arched or pronated foot, or pes planus, and 3. high arched or supinated foot, or pes cavus [34, 35]. Normally aligned foot is defined as the

foot in which the bisection of the posterior surface of the calcaneus is perpendicular to the ground and its arch height is within normal range. Pronated foot is defined as the foot in which the calcaneus is everted and its arch is low or absent. Supinated foot is defined as the foot in which the calcaneus is inverted and its arch is high. The supinated foot is more rigid with limited shock absorption ability, prone to higher stress underneath the heel and more force passing to the tibia and femur. The pronated foot, with a greater ground contact area, is more flexible, leading to the load to be absorbed by the musculoskeletal structures of the foot. A higher plantar pressure on midfoot was observed for the people with pronated foot during walking [36]. The arch structure might be associated with different injury patterns. Williams et al.[37]reported that high-arched runners exhibited more bony, ankle and lateral injuries but low-arched runners revealed a higher risk of soft tissue, knee and medial injuries.

In the general community, population studies showed the prevalence of pes cavus and pes planus to be 5–10% and 3–19%, respectively[38-40]. Both pes cavus and pes planus are associated with long term pain and lead to deficits in balance and mobility [41, 42]. Pes planus, characterized by a depressed longitudinal arch and hind foot valgus and/or forefoot abduction [43]

Cavus and planus feet can present asymptomatically or symptomatically over a wide range of severity and discomfort; some asymptomatic feet with high or low arches could be considered part of the continuum of “normal”—this is especially true for flat feet. As such, planus feet were divided into two groups: asymptomatic feet that were flat, but pain free, and symptomatic flat arch feet that presented with pain, often in the medial malleolus and medial arch[42]. Why Symptoms are present or not is not understood.

Foot posture, like most human anthropometric characteristics, varies considerably among children, adults and the older population [44]. Some variations in foot posture are associated with changes in lower limb motion [45, 46]and muscle activity [47], and are strongly influenced by some systemic conditions, such as neurological [48] and rheumatological diseases [49]. These factors add weight to the view that functional differences exist between different foot types.

Research into the shape, structure, and function of the foot arch has never ceased. But as far as

my knowledge is concerned there is no research done about the relation of foot type and podoconiosis.

1.3 Statement of the problem

Podoconiosis is also known as endemic non-filarial elephantiasis of the lower legs and is thought to be caused by prolonged exposure of the feet to red clay soils of volcanic origin. Walking barefoot, which is a common practice among poor agricultural people in tropical highlands, is a common risk factor resulting in exposure to irritant clay soil particles . This prolonged exposure when matched with genetic susceptibility to the disease results in damage to the lymphatic vessels and swelling of the lower legs over time [2, 10, 12].

One million cases are estimated to exist in Ethiopia, and 64% of these are in the economically productive age group. The average prevalence of the disease in Ethiopia is greater than 5% in endemic areas [3]. In Wolaita Zone of southern Ethiopia, one study showed that the disease results in an annual economic loss of 16 million USD [22]. Through direct projection from these 2005 figures, the economic loss in Ethiopia due to podoconiosis is estimated to be more than 200 million USD per year [5, 22].

A disease is deemed to be of public health importance on the basis of either high mortality or morbidity. The disease burden imposed by non-fatal causes of disease affects low and middle income countries more than developed ones. This adds poor quality of life to the short life span of the population in the developing world[50]. Podoconiosis is one such non-fatal diseases, resulting in pronounced disfigurement and debilitation among affected individuals [51]. In podoconiosis-endemic areas the disease is more prevalent than fatal diseases such as HIV/AIDS[10].

podoconiosis causes chronic disability and morbidity rather than death [13]. In addition to the high burden of disability, the social, economic and psychological sequelae are significant [22, 26, 27]. These include isolation, exclusion from community events [28] and barriers to employment, education and marriage [26]. These are key activities for both social and economic well-being.

Podoconiosis is an important yet neglected problem of social, economic, development and public health relevance in endemic countries. The disease has recently gained global and national attention. It has recently been recognized by the World Health Organization (WHO) as a neglected tropical disease (NTD) because of the disabling impact it has on affected communities [16]. The Federal Ministry of Health of Ethiopia (FMOH) has also endorsed inclusion of podoconiosis in the National Master Plan for Neglected Tropical Diseases [52].

Although local NGOs like Mossy Foot Treatment and Prevention Association (MFTPA) was established specifically to provide treatment and care for patients with podoconiosis in Wolaita zone [53]; International Orthodox Christian Charities (IOCC) in the town of Debre markos to provide podoconiosis care or support services the problem is still huge.

The role of environmental triggers, particularly soil minerals, in the development of podoconiosis has been described by earlier studies. However, individual correlates have not been conducted in depth. Yet, the association between foot type and podoconiosis is unknwon .

The disease only affects some barefoot individuals - not all exposed individuals develop podoconiosis. It is a multifactorial disease with evidence of genetic susceptibility and environmental exposure. Which type of foot is more liable for the occurrence of podoconiosis? is there association between foot type varieties and podoconiosis? The aim of the study is to investigate the association between foot type varieties and podoconiosis and other individual covariates among podoconiosis confirmed cases?

1.4 Significance of the study

Previous podoconiosis studies have benefited from the inputs of multiple disciplines (the Interdisciplinary) approach; brought together to address the problem comprehensively. Epidemiology, genetics, economics and behavioural studies are some of the disciplines used in the study of podoconiosis in Ethiopia. This approach not only helps to understand podoconiosis from different angles, but also supplements understanding of one's own area of expertise. Similarly, this study of the retrospective comparative study of association between foot Parameters (foot arch)& podoconiosis requires expertise from anatomy.

In our knowledge this study is the first in the world which may open insights for anatomists to study further about podoconiosis. The study will identify which type of foot arch is more liable in podoconiosis occurrence, which will in turn enhance implementation of intervention program in other similar settings. This study will also identify other individual covarities like age,sex ,shoe-wearing habit & foot hygiene.

The study will also give a good insight not only for future studies in other parts of the world affected by podoconiosis; but also for other diseases with individual components. Moreover, utilization of different techniques and exploration of range of correlates that coexist naturally makes this study amenable for implementation.

Hopefully, study participants will be benefited from the research. That is; they have the right to know their current condition: podoconiosis staging and bone density. More over the researcher will report the participants contribution for this scientific research so that participants will be prioritized in any NGOs aid particularly for IOCC in provision of care

1.5 Objectives

1.5.1 General objective

To assess the association of foot type and podoconiosis and other individual covariates of Podoconiosis, North west Ethiopia, 2018

1.5.2 Specific objectives

- To describe type of foot among individuals living in podoconiosis endemic area, North West Ethiopia, 2018.
- To determine the association between foot type and podoconiosis, North west Ethiopia, 2018.
- To identify individual correlates with podoconiosis, North West Ethiopia, 2018.

LITERATURE

2.1 Available materials on prevalence & socio-demographic factors of podoconiosis

The podoconiosis group contained significantly more illiterate individuals (p=0.013) and a higher proportion of people with lower levels of education (p=0.006), particularly secondary education; lower average income (p<0.001) and more individuals in the lower income quintiles (p<0.001); and fewer married individuals (p<0.001). The distribution of occupations within the two groups was also significantly different, withthe podoconiosis group containing fewer farmers and moretraders than the healthy group[54].

Almost all patients were in the age group 15-64 (the age group that includes economically active individuals in Ethiopia), did not read or write, and were farmers. On average, patients had lived in the study area for 40 years. More male than female patients were married (84.6% vs. 53.6%, $\chi^2 = 157.1$, $p < 0.0001$) and divorce was more common among women than men (22.5% vs. 3.6%, $\chi^2 = 102.3$, $p < 0.0001$)[55].

The prevalence was 3.3% (95% CI = 3.1% to 3.6%) in Debre Eliyas and 3.4% (95% CI = 3.2% to 3.6%) in Dembecha w*oredas*. The male to female ratio was 0.98:1. More than 87% of the patients fell within the 15 to 64 year age group, and less than 2% were under the age of 15 years[55].

2.2 Available materials on onset, exposure, preventive behavior & familial cluster of podoconiosis

The median age of onset of leg swelling was 22 years (range: 10 to 77 years). On average, patients sought treatment 5 years (SD = 6.9) after the start of the leg swelling, predominantly at health centres (39.8%) and from traditional healers (39.1%)[55]

More study subjects had symmetric bilateral swelling than unilateral or asymmetric bilateral swelling. Most subjects had second or third clinical stage disease. Nearly all (97.9%) patients had mossy lesions and 53% had open wounds on at least one of their legs[55].

Clustering of podoconiosis patients within a family was observed. A total of 40% of participants said that there were other patients in their family, of whom most were first (22.5%) or second (13.6%) degree relatives [55].

The median ages of first use of shoes and socks in the area were 22 and 23 years, respectively.

About 40% of the patients said that they had one pair of shoes. More men than women owned more than one pair of shoes (61.1% vs. 50.5%; $\chi^2 = 11.6$ $p = 0.001$). Most study participants suggested that they needed three pairs of shoes per year [55].

;The types of shoes worn by the study participants at the time of interview were covered hard plastic (33.3%) followed by canvas (20.9%) and *berebaso/gilet* (open sandals locally made from tyres) (13.2%). During the interview, 23.6% of the respondents were observed to be barefoot of whom most (65.3%) were women. Menwere more likely to wear open, non-protective shoes. There was no statistically significant association between gender and use of protective shoes (p = 0.92)[55].

Based on patients' estimates, the average one-way walking time to the nearest water source for washing feet was 19 minutes (SD = 15.7). The average one-way walking time to the nearest field and nearest market were 20 minutes (SD = 14.9) and 54.5 minutes (SD = 50.1), respectively. On average, the respondents travelled to their nearest field and to market nine (SD = 10.9) and four (SD = 3.9) times per month, respectively[55].

On observation, 46.8% of patients had clean feet, 25.1% had dirty feet, 13.9% had cracked feet and 13.9% had both dirty and cracked feet. The reported average frequency of foot washing was seven times a week. There was no statistically significant difference between men and women in the frequency of foot washing ($p = 0.12$) and foot washing with soap ($p = 0.33$)[55].

Almost all of the cases and controls, 99.6% and 99.9% respectively, were able to get enough water to wash their feet. There was no significant difference in accessing piped water between cases and controls living in 'high' endemicity areas (47.6% vs. 52.4%, $X2 = 0.1$, $p = 0.788$), but piped water was more common (49.1%) in 'low' endemicity areas while well water was more common (39.1%) in 'high' endemicity (1)areas. There was no significant difference between cases and controls in the frequency of foot-washing per week; both groups said they washed eight times per week on average. Similarly, both groups said they used soap on average four times per week while washing their feet. Comparing foot-washing practices for people living in 'high', 'medium' and 'low' endemicity areas: frequency of foot-washing was higher in 'high' endemicity areas than in 'medium' or 'low' endemicity areas (mean (SD) = 8.7 (3.0) vs. 7.6 (2.6) and 7.6 (2.6) f = 23.3, $p < 0.0001$), but there was no difference between cases and controls living in the 'high' endemicity areas (mean (SD) = 8.7 (3.1) vs. 8.6 (2.9) $f = 0.08$, $p = 0.782$). The results were the same for washing with soap.

There was no statistically significant difference in 'ever' owning shoes between cases and controls (53.4% of cases and 51.5% of controls had 'ever' worn shoes, $p = 0.528$). Among those that had 'ever' owned shoes, 223 (90.3%) of cases and 354 (97.5%) controls owned some type of shoe at the time of the interview (*X2 comparing proportions* = 15.1, $p < 0.0001$). People in 'high' and 'medium' endemicity areas were less likely than people in 'low' endemicity areas to have 'ever' owned shoes (OR = 0.49, 95% CI = 0.37 to 0.67, $p < 0.0001$), and the same pattern was seen among controls. Affected men had greater odds than affected women to have 'ever' owned shoes (OR = 3.7, 95% CI = 2.5 to 5.4, $p < 0.0001$). The most common type of shoes owned by the cases were: closed plastic shoes (60.7%), canvas shoes (31.3%), tyre sandals (26.8%) and plastic sandals (18.3%). Shoes owned by controls were: closed plastic (59.9%), closed leather (48.0%), canvas (32.5%) and sandals (29.4%). During the interview 322 (70.8%) cases and 521 (76.8%) controls were observed to be barefoot. The types of shoes that the study subjects wore were classified into protective (wearing closed shoes) and non-protective (barefoot or wearing open shoes). At interview, 367 (80.7%) cases (of whom 322 were barefoot) were classified as 'not protected' compared to 568 (83.8%) controls (of whom 521 were barefoot). This difference was not statistically significant (*X2 = 1.7, p = 0.18*). More affected men than women owned shoes (69.9% vs. 38.7%, $X2 = 44.8$, $p < 0.0001$) and wore shoes classified as protective (26.0% vs. 13.3%, $X2 = 11.8$, $p = 0.001$). The gender difference also existed in the control group where male controls used protective shoes more than female controls (21.7% vs. 7.6%, $X2 = 23.5$, $p < 0.0001$) [55].

2.3 Available materials on normal values & measurements of foot type

The overall mean (SD) of the NH was found to be 2.89 (0.54) (range 1.9–4.2) cm, FCH 2.08 (0.44) (range 0.8–3.0)cm, CIA 16.57° (3.30°) (range 12°–26°), and C1MA 140.05° (5.63°) (range (122°–155°). The mean (SD)of CH and C5MA was found to be 1.19 (0.31) (range 0.60–1.9) cm and 160.96° (4.69°) (range 151°–176°),respectively[56].

Mean (± 1 SD) maximum values for NH, LAA, and FL were 4.6 cm (0.9 cm), 141.8 cm (10.4 cm), and -1.9°(0.7°), respectively[57].

Normal maximum MLA and MLA ROM were for NH between 3.6 and 5.5 cm and between 0.6 and 1.8 cm, respectively. For LAA normal maximum values were between 131 and 152° and normal ROM values were between -1 and 13°. Normal maximum FL values were between -1.2

and -2.6 cm and normal FL ROM values were between -0.1 and 0.9 cm. These values represent the 68% prediction limits[57].

figure 2: Lateral views : calcaneal inclination angle(A); calcaneal-first metatarsal angle(B) [58]

Age only had a significant association with maximum LAA values among males. Among males, foot length was associated with ND and maximum LAA and FL. Work performed on the day of testing , BMI and number of years performing standing work had little or no association with mid foot measures[57].

Foot posture index (FPI) is a diagnostic clinical tool aimed at quantifying the degree to which a foot can be considered to be in pronated , supinate or neutral position[59].

It is intended to be a simple method of scoring the various features of foot posture into a single quantifiable result which in turn gives an indication of the over all foot posture[59].

The six clinical criteria employed in the FPI-6 are[59]

1. Talar head palpation 2.Supra and infra lateral malleolar curvature 3.Calcaneal frontal plane position 4. Prominence in the region of the talonavicular joint 5.congruence of the MLA 6.Abduction /adduction of the fore foot on the rear foot .

The final FPI score will be a whole number between -12 and +12[59].

2.4 Conceptual framework of the study

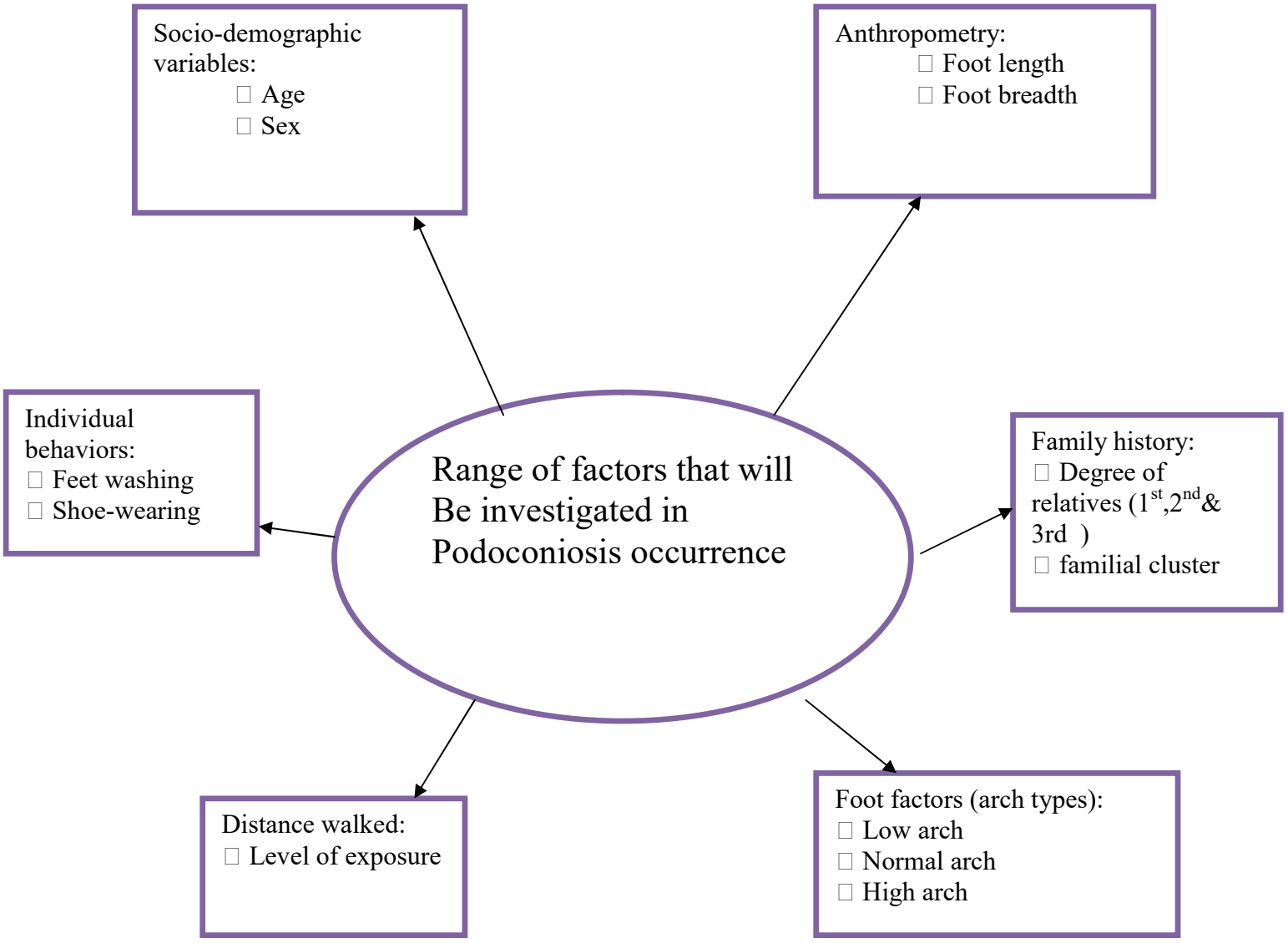

Figure 3 : Conceptual framework of the study

METHDOLOGY

3.1 Study setting

The study was conducted in A community-based and hospital based comparative cross sectional study in East and West Gojjam Zones, Northern Ethiopia, in December 2017. East and West Gojjam Zones are at an average elevation of 2,769 and 2,466 meters above sea level, respectively. West Gojjam Zone has an estimated total population of 2,106,596, and East Gojjam Zone of about 2,152,671, 150 Households [17]. The economy of both zones is reliant on predominantly plough- based (traditional) agriculture. Farmers depend on mähär (the main rainy season from June to September) crops, which provide more than 95 percent of the total agricultural production. In 2013, the prevalence of podoconiosis among people aged 15 years and above in these Zones was found to be 3.3%, and 87% of cases were in the economically active age group [60]. Identification of the study area was based on a report by the International orthodox Christian charities (IOCC) podoconiosis treatment center, written in 2010, summarizing information from key local informants.

Podoconiosis has been found to be prevalent in this area& there was no filariasis case found in the two zones in a baseline survey in November 2011prior to establishing a podoconiosis treatment service in the area[19].

Seven Kebelles which were podoconiosis endemic area were selected for the study. These were chosen on the basis of having the highest prevalence of podoconiosis identified by the investigator exhaustive observation of different Kebeles of the woreda & considering nearest Kebelles for hospital. The study population constitutes those patients identified by the 2011 survey, and their neighbors without podoconiosis in Jabihetenan woreda.

3.2 Study design and participants

Comparative cross-sectional study design with both clinical and radiographic measurements was used to determine foot type in the study. It compared two distinct study groups - a case group with clinically confirmed adult patients with podoconiosis, and healthy adult neighbours as controls. A quantitative methodology was applied for the study, as the primary aim was to establish whether type of foot is associated with podoconiosis.

3.3 Sources population

The cases was selected based on the population of patients with podoconiosis identified in the Aforementioned surveys. The controls was taken from non-affected individuals neighboring the cases.

3.4 Actual study population

Selected cases and controls.

3.5 Inclusion and exclusion criteria

Adult podoconiosis cases and controls neighboring cases age >=18years and <= 65 years and lived in the study area at least for the last ten years will be included in the study and those who had any history of neurological deficit and trauma as well the first onset of podoconiosis not greater than ten years were excluded.

3.6 Sample size

For this Comparative cross-sectional study, data was excruited from selected high prevalent seven kebeles through convenient method. So that 100 cases and neighboring 50 controls was selected ; in which one control was selected for two case.

3.7 Sampling procedures

Initially the researcher selected previously trained local podoconiosis association coordinators & members & had delivered training for five days in Finote selam Bakel health center about the objective of the research, facts related to prevention & care of podoconiosis. Again they had been trained how to recruit consented podoconiosis cases & healthy neighboring controls ; and the issue of payment as well minimal risk for cases exposed for x-ray. Then 100 consented cases & 50 consented controls were came under the guide of the seven coordinators to Burie Asrade governmental Hospital. Samples were selected based on availability, convenience & after the researcher got consent from each participant.

3.8 Data collection procedures

Socio - demographic, behavioral, anthropometry and familial history characteristics of both cases and controls was collected via structured questionnaires & anthropometric tools in the hospital . Foot characteristics for controls was obtained viaFPI-6 and for cases via digital lateral & AP angular x-ray at Burie Asrade governmental hospital.

3.9 Data Management

Data quality was managed via training for coordinators by the researcher ; for data collectors (radiographers for cases & anatomists for controls) by co-advisor & the researcher , pretest to check questionnaires and by using standardized instruments as well incomplete image was screened by the radiologist & taken again to fill the gap. Moreover data was entered & cleaned by EpiData3.1.

3.10 Data Analysis procedures

After data was entered and cleaned, it was exported to IBM SPSS V 20 for analysis. Initially Univarate analysis was done for every independent variables then bivarate analysis between every independent predictor and predicted variable was checked for its crude odds ratio , significance(p value) and confidence interval. Finally those which show significant effect was fitted in to the logistic regression so that adjusted odds ratio , P value and confidence interval was determined for predictors of dependent variable.

3.11. Operational definition

Controls: healthy individuals who are neighbors'' of cases.

Podoconiosis: confirmed cases characterized by swelling of lower extremities.

Normarl foot/arch : those whose FPI with in -2 and +2 for controls and CIA with in 12 and 26 ^{0} for cases .

Foot planus /Low arched: those whose FPI is less than -2 for controls and CIA less than 12^{0} for cases .

Foot cavus /high arched: those whose FPI greater than +2 for controls and CIA greater than 26^{0} for cases .

3.12 Ethical consideration

Ethical clearance was obtained from Department Research Ethics Review Committee (DRERC) of Anatomy department in School of Medicine of Addis Ababa University and Amhara regional state health bureau. A formal letter was also submitted to all concerned bodies to obtain their co-operation. Data collection was conducted after verbal and written consent was obtained from participants, which was taken from each selected participant after explanation of the study

purpose, description of the benefits and an offer to answer all inquiries was made to the respondents. It was explained that answering the interview questions have no harm on the participants and that their participation will help to create awareness concerning the issue. Again cases were informed as there may receive low radiation effect. Also affirmation that they are free to withdraw collected information was ensured.

3.13 Dissemination of results

The study conducted for the partial fulfillment for the requirement of degree of Masters in Addis Ababa University, college of health sciences, school of Medicine, Department of Anatomy and the result of the study will be submitted to the institute. The study findings will also be given to relevant bodies such as Amhara regional state health beauro, Ethiopian public health institute , IOCC and other responsible governmental and non-governmental organizations to serve as current source of information on the issue. Effort will be made to publish in peer- reviewed journal especially in lancet.

4. Results

4.1 Socio demographic characteristics of the respondents

A total of 144 households with 144 members aged 18 years and above were included in the study. Of the study participants a total of 94 podoconiosis patients that provided consent participated in the detailed patient interview and foot lateral angular radiological examination. Almost all patients (99.0%) were in the age group 15-64 (the age group that includes economically active individuals in Ethiopia), did not read or write (65.0%), and were farmers (87.0%)(see **Table 1**).

Table 1 : Socio-demographic Characteristics of respondents, west Gojjam, North West Ethiopia, 2018/19 (n = 144)

Characteristics	Category	Cases	Controls	Total
Age(in years)	18-24	11(7.6%)	9(6.2%)	20(13.8%)
	25-34	30(20.8%)	12(8.3%)	42(29.1%)
	35-44	27(18.8%)	15(10.4%)	42(29.2%)
	45-54	19(13.2%)	6(4.2%)	25(17.4%)
	55-65	7(4.9%)	8(5.6%)	15(10.4%)
	Total	94(65.3%)	50(34.7%)	144(100%)
Sex	Male	46(31.9%)	30(20.8%)	76(52.8%)
	Female	48(33.3%)	20(13.9%)	68(47.2%)
	Total	94(65.3%)	50(34.7%)	144(100%)
Education level	Cannot read/write	61(42.4%)	14(9.7%)	75(52.1%)
	Can read/write	33(22.9%)	36(25.0%)	69(47.9%)
	Total	50(34.7%)	94(65.3%)	144(100.0%)
Occupation	Farmer	82(56.9%)	44(30.6%)	126(87.5%)
	All others	12(8.3%)	6(4.2%)	18(12.5%)
	Total	94(65.3%)	50(34.7%)	144(100.0%)
Religion	Orthodox Tewahido	94(65.3%)	49(34.0%)	143(99.3%)
	Muslim	0(0.0%)	1(0.7%)	1(0.7%)
	Total	94(65.3%)	50(34.7%)	144(100.0%)

Table 2 : Socio-demographic Characteristics of respondents, west Gojjam, North West Ethiopia, 2018/19 (n = 144) … continued.

Characteristics	Category	Cases	Controls	Total
Ethnicity	Amhara	94(65.3%)	50(34.7%)	144(100.0%)
Residence	Urban	6(4.2%)	11(7.6%)	17(11.8%)
	Rural	88(61.1%)	39(27.1%)	127(88.2%)
	Total	94(65.3%)	50(34.7%)	144(100.0%)
First language	Amharic	93(64.6%)	50(34.7%)	143(99.3%)
	Wolaitegna	1(0.7%)	0(0.0%)	1(0.7%)
	Total	94(65.3%)	50(34.7%)	144(100.0%)
Marital status	Single	19(13.2%)	0(0.0%)	19(13.2%)
	Married	47(32.6%)	43(29.9%)	90(62.5%)
	Divorced	24(16.7%)	2(1.4%)	26(18.1%)
	Widowed	4(2.8%)	5(3.5%)	9(6.2%)
	Total	94(65.3%)	50(34.7%)	144(100.0%)
Income in ETB	< 500	65(45.1%)	8(5.6%)	73(50.7%)
	500-1000	24(16.7%)	7(4.9%)	31(21.5%)
	>1000	5(3.5%)	35(24.3%)	40(27.8%)
	Total	94(65.3%)	50(34.7%)	144(100.0%)
Body mass index	< 18.5	18(12.5%)	11(7.6%)	29(20.1%)
	18.5– 25	75(52.1%)	38(26.4%)	113(78.5%)
	>25	1(0.7%)	1(0.7%)	2(1.4%)
	Total	94(65.3%)	50(34.7%)	144(100.0%)

Table 3 : Univarate analysis of respondents for scale variables, west Gojjam, North West Ethiopia, 2018/19 (n = 144)

Characteristics	Category	Cases	Controls	Total
Age	Mean (±SD)	37.24(10.79)	38.06(12.06)	37.53(11.21)
	Median (Min-Max)	37(18-61)	37(22-65)	37()18-65
Monthly Income	Mean (±SD)	531.38(554.26)	2997.20(1916.73)	1387.57(1687.14)
	Median (Min-Max)	400(0-4000)	3250(0-7000)	500(0-7000)
Average age for first shoes	Mean (±SD)	28.01(11.56)	21.30(10.13)	25.87(11.51)
	Median (Min-Max)	27(3-55)	20(8-50)	25(3-55)
Minutes walked to furthest field one way	Mean (±SD)	43.56(21.47)	67.20(17.27)	51.77(23.01)
	Median (Min-Max)	40(10-90)	70(20-90)	50(10-90)
Minutes walked to nearest field one way	Mean (±SD)	13.88(8.49)	15.38(7.85)	14.40(8.28)
	Median (Min-Max)	10(5-50)	15(3.30)	10(3-50)
Minutes walked to water source one way	Mean (±SD)	15.23(8.57)	20.90(16.74)	17.20(12.29)
	Median (Min-Max)	10(5-40)	17.5(5-90)	15(5-90)
Minutes walked to kebele work one way	Mean (±SD)	36(9.66)	43.21(15.41)	41.32(14.36)
	Median (Min-Max)	30(30-60)	40(20-90)	40(20-90)
Minutes walked to funeral one way	Mean (±SD)	34.06(16.9)	38.04(16.68)	35.65(16.85)
	Median (Min-Max)	30(15-90)	40(10-90)	30(10-90)
Religious institution	Mean (±SD)	29.57(8.30)	30.85(12.06)	30.09(12.89)
	Median (Min-Max)	30(20-60)	30(10-90)	30(10-90)
Time walked to regular market one way (mins)	Mean (±SD)	61.22(16.88)	41.40(22.09)	54.34(21.03)
	Median (Min-Max)	60(15-90)	40(10-90)	60(10-90)

The foot types of the respondents in podoconiosis endemic area are high arched eighteen (12.5%) , normal arched eighty four (58.33%) and low arched 42 (29.16%). Seventeen percent (18.0 %) of the healthy respondents and 35.11% of cases are low arched foot types (see figure 4).

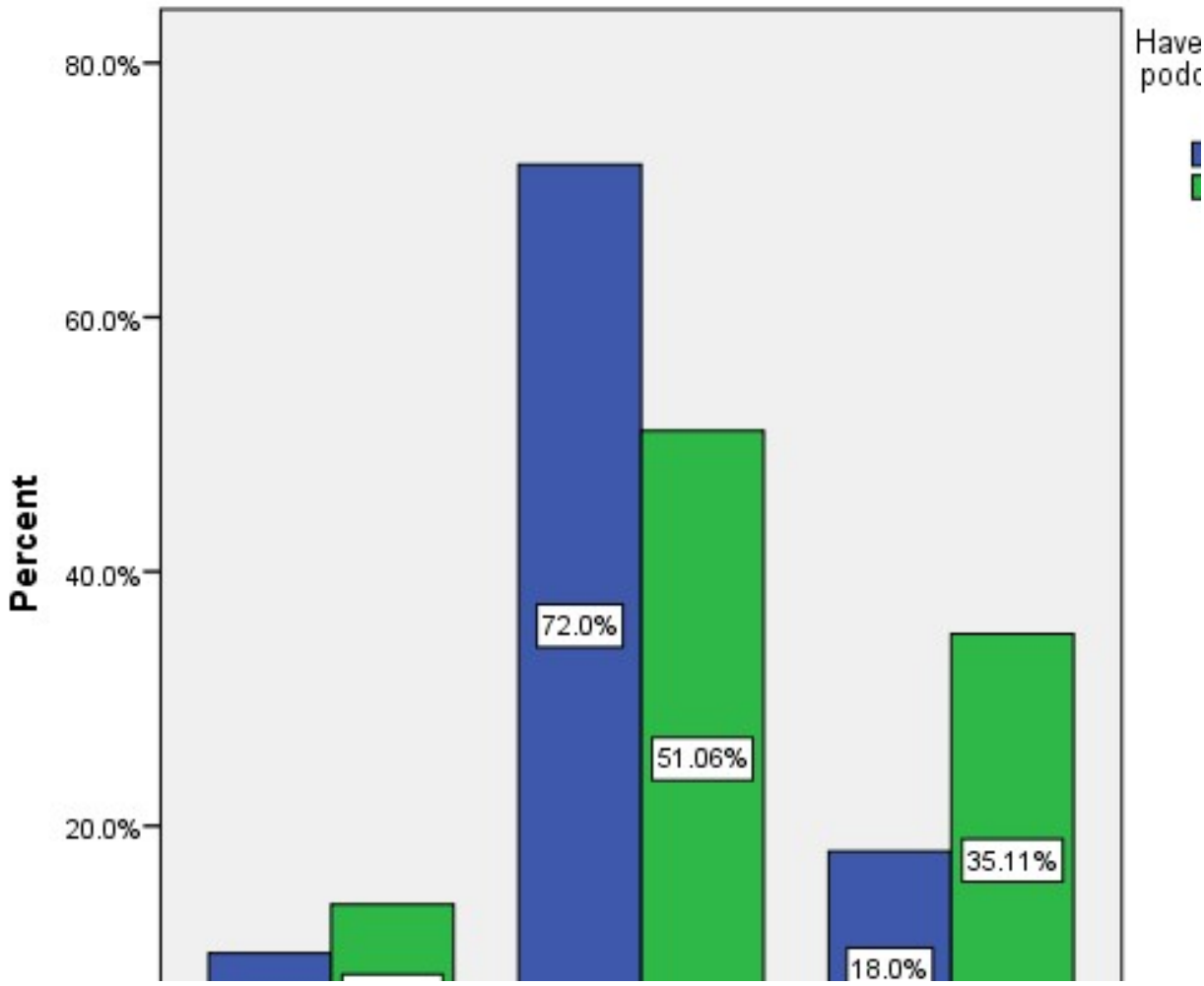

Figure 4 : Foot arch of respondents; Gojjam , North west Ethiopia , 2018/19

The calcaneal inclination angle of cases were less than sixteen for 35.11% of cases, between sixteen and twenty four including twenty and twenty four for 51.06 % of cases and greater than twenty four for 13.83% of cases .

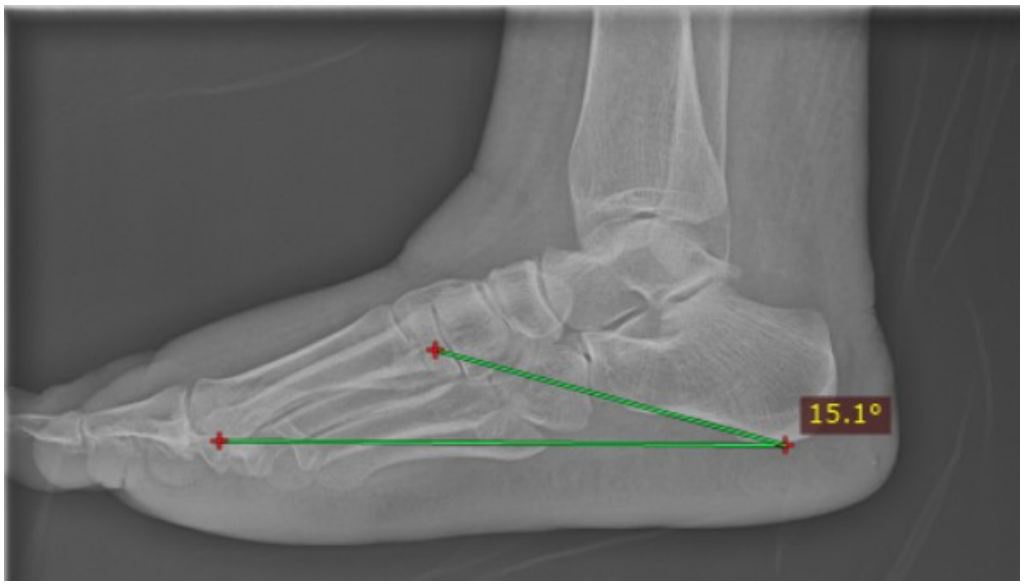

Figure 5 : Calcaneal inclination for flat arched cases in North west Ethiopia , Gojjam , 2018/19

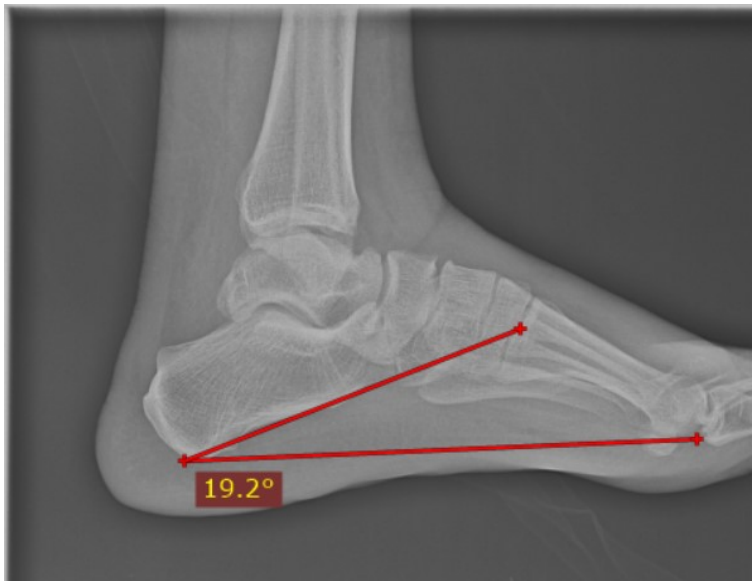

Figure 6 : Calcaneal inclination for normal arched cases in North west Ethiopia, Gojjam , 2018/19

Figure 7 : Calcaneal inclination for high arched cases in North west Ethiopia, Gojjam , 2018/19

4.2 Bivariate and multivariate analyses of covariates for cases and controls

In adjusting the final model reference groups for explaining each response group were literate for educational level, married for marital status, and low arched for foot arch types respectively .

Educational level, marital status, monthly average income, age for first shoe wears and foot type was adjusted to the model. In the model we have seen $X^2(6, N=144)=81.391$, $P<0.001$ and between fifty four percent and seventy one percent of variance in the dependent variable is explained by the model. Eighty six percent was predicted correctly.

Those who are illiterate, un married were more affected by podoconiosis (AOR = 3.378, p=0.079 and AOR = 8.664, p = 0.027). The average monthly income is the other finding which is associated with podoconiosis development (AOR =0.999, p< 0.001). Individuals who were shoes early in their life are less likely to develop podoconiosis (1.075, p = 0.018). The population with low and high arched are more likely to develop podoconiosis (AOR = 2.096 and AOR=15.383) respectively.

Table 4 : Bivariate and multivariate analyses of covariates for cases and controls

Variable	Category	Bivariate analysis	Multivariate analysis
		Crude odds ratio (95%CI), P value	Adjusted odds ratio (95 % CI), P value
Sex	Male	0.369 (0.319 to 1.281), p=0.207	Not adjusted in to final model
	Female	1.565 (.781 to 3.138), p=0.207	Not adjusted in to final model
Marital status	Married	0.163(0.066 to 0.399) , p<0.0001	
	Unmarried	6.143(2.509 to 15.038), p<0.0001	8.664(1.286 to 58.362) p = 0.027
Educational level	Literate	0.210(0.1 to 0.445) , p<0.0001	
	Illiterate	4.753(2.248 to 10.049), p<0.0001	3.378(0.867 to 13.167), p=0.079
Ever owned shoes	Yes	1.580(0.800 to 4.282), p=0.151	
	No	0.540 (0.234 to 1.251) , p=0.151	
Currently owns shoes	Yes	0.338(0.039 to 2.914), p=0.324	Not adjusted in to final model
	No	2.959 (0.343 to 25.511) , p=0.324	
Foot arch	High	0.709 (0.200 to 2.519), p=0.595	15.383(0.956 to 247.465),p=0.054
	Normal	0.364(0.155 to 0.855), p=0.02	
	Low	0.364(0.155 to 0.855), p= 0.02	2.096(0.495 to 8.866), p=0.315
Age distribution		0.994(0.964 to 1.024), p=0.677	Not adjusted in to final model
Average monthly income		0.998(0.998 to 0.999), p<0.0001	0.999(0.998 to 0.999) , p< 0.0001
Average age for first shoes		1.059(1.018 to 1.101) , p=0.005	1.075 (1.012 to 1.141) , p = 0.018

The final logit model equation for factors associated with podoconiosis development is:

Log (podoconiosis) = 1.358+1.217 education level -2.159 marital status + .016 income -.697 average age for first shoes-.291 high arched -.535 normal arched

All cases had been bilateral edematous leg. Of which 72.34% and 69.15 % were stage three for right leg and left leg respectively. This implies as podoconiosis is bilateral and most of the time symmetrical diseases that affects lower leg. See figure

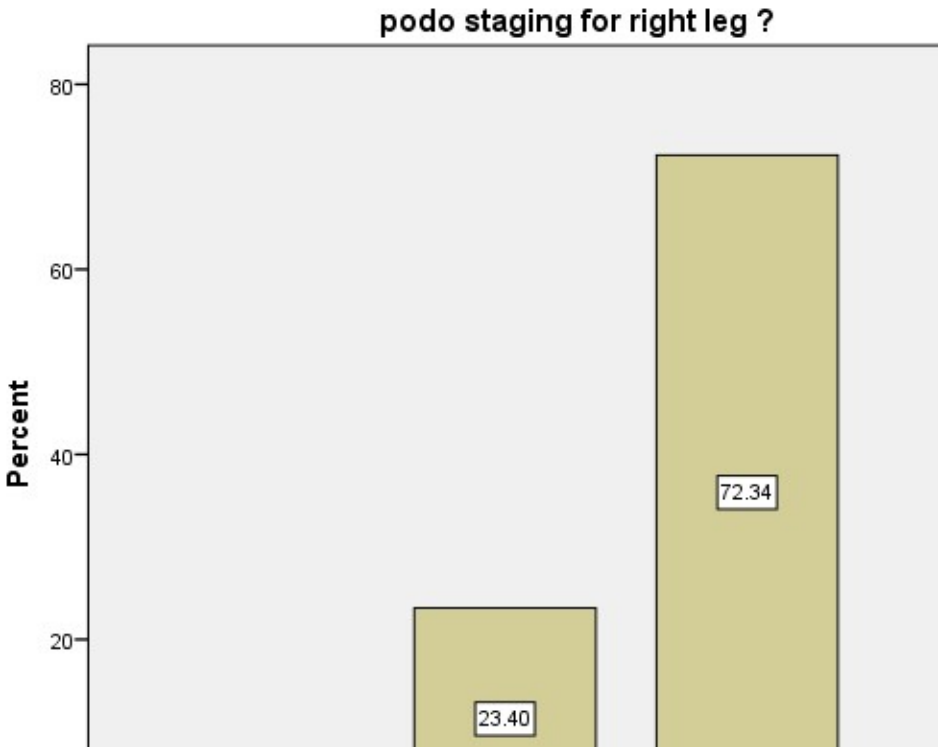

Figure 8 : Podoconiosis staging for right leg (n=94)

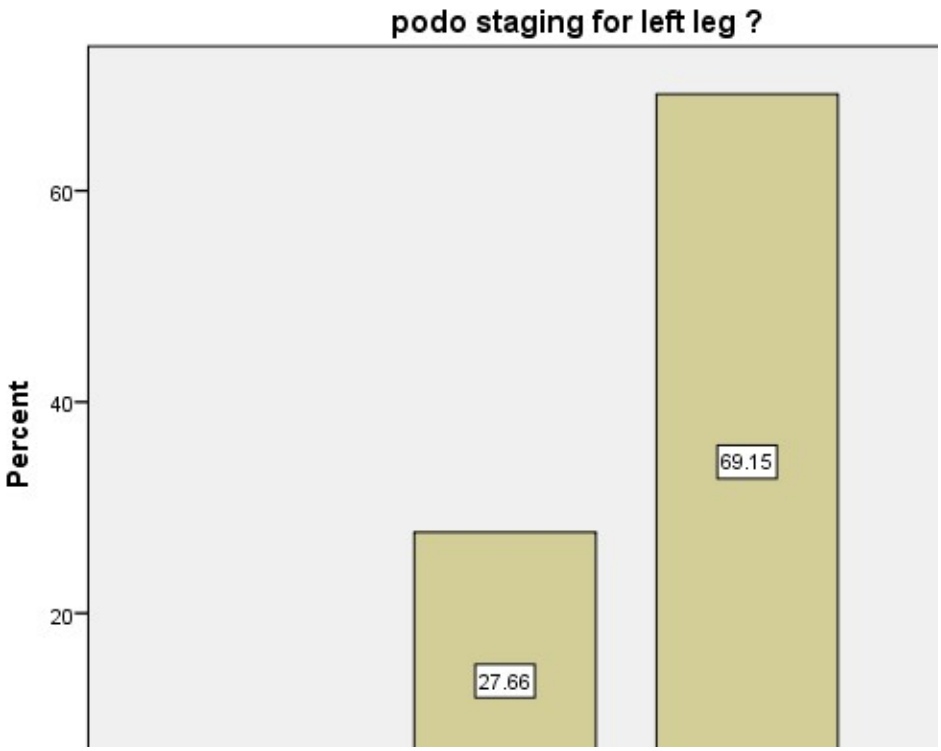

Figure 9 : Podoconiosis staging for left leg (n = 94)

Of the total (n = 94) podoconiosis cases 30(31.9%) respondents have podoconiosis affected families. Of the affected families first degree families are the dominant one (80%) see figure

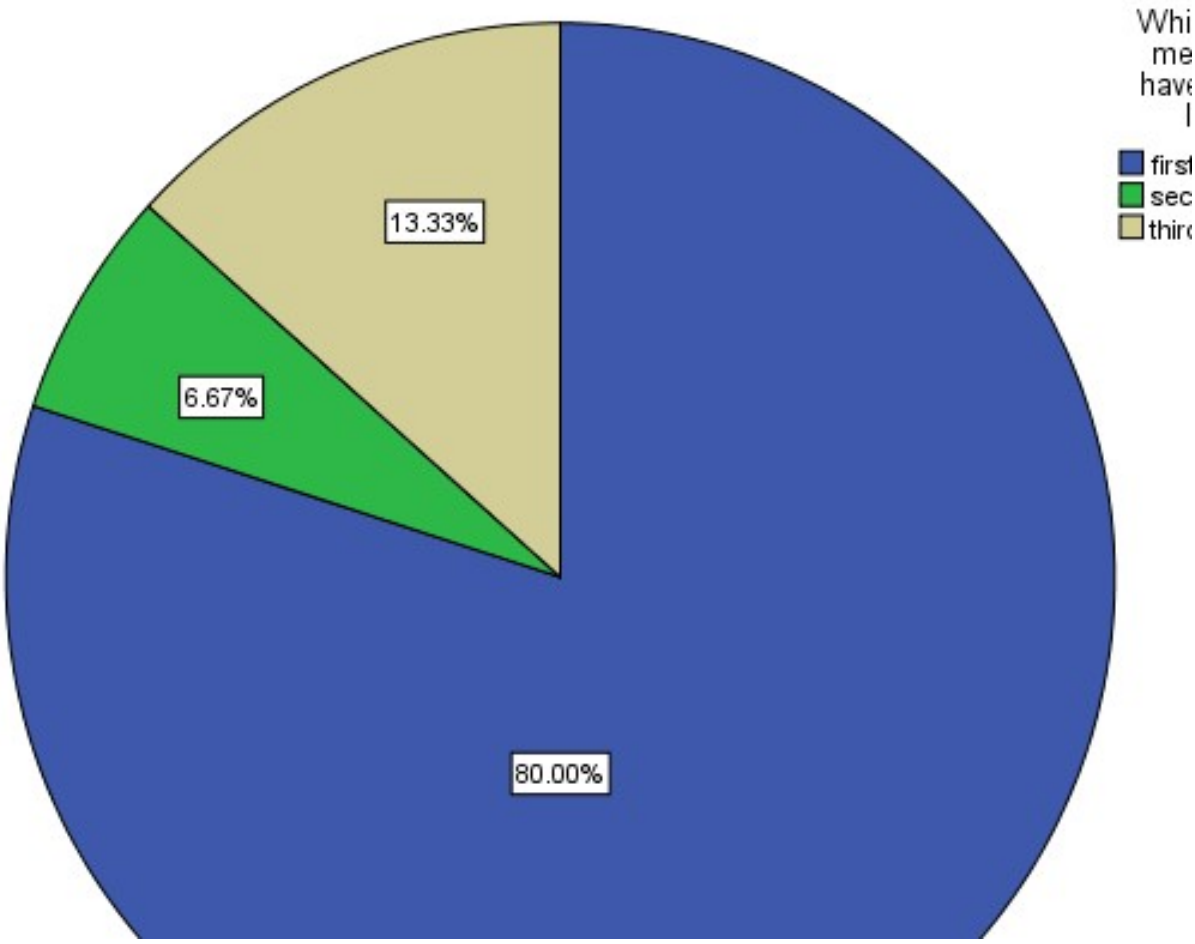

Figure 10 : Familial clustering of podoconiosis of respondents, North West Ethiopia, 2018/19

5. Discussion

The risk factors associated with podoconiosis is multifactorial and the exact etiology and pathogenesis is still unknown. The study tries to investigate the foot factors as it is associated with podoconiosis development or not. In global milieu the study in line with my knowledge is the first research that can be baseline for future exploration of foot factors in the development of podoconiosis.

Foot which is the interaction point between the body and the ground is not well studied as if associated with different neglected tropical diseases. The association between foot shape and clinical disorders is poorly defined. Low arched and high arched runners are more likely to develop medial and lateral foot injuries (Williams et al., 2001). In our study low and high arched community members who are above age eighteen are more likely to develop podoconiosis. This may be the low arched foot exposes individuals in more surface area to volume ratio for the ground so that the chance of the silica to penetrate the foot will be increased where as for those who are high arched individuals the plantar pressure between the foot and the ground is high than other foot types that may again give the opportunity for red silica to penetrate the skin of the foot.

The distribution of foot types in podoconiosis endemic areas are twelve point five percent, fifty eight point three percent and twenty nine point one six for high, normal and low arched respectively which is higher in comparison with the general community, population studies that showed the prevalence of high arched and low arched foot to be 5–10% and 3–19%, respectively (Burns J. et al. 2007). The foot type prevalence in our study can be used as a standard for either research or clinical management references due to the researcher was utilized standared tools for the determination of foot types.

The study find that as income increased the likelihood of developing podoconiosis is decreased. The finding is comparable with the result of (Molla Y. et .al 2014) in which podoconiosis was associated with low income. This may be those who have high income may have the chance to by shoes for protecting their foot than others .Again the age for first shoe wear is another factor which was associated with podoconiosis development. As the age of individuals to wear shoes for the first time increased the likelihood of podoconiosis development is increased.

Conclusion and recommendation

The study broadens to consider risk factors associated with podoconiosis development. Foot type which was only considered for the first time in podoconiosis research is associated with development of podoconiosis slightly significant. The study winds up with individuals who have low arched foot are more affected with podoconiosis than other foot types. The findings of the study also reassure podoconiosis affects more the poor and illiterate population than the rich and literate population living in red clay alkalic environment favorable for clay degradation.

For this the researcher suggests large scale combination of foot parameters and genetics should be done for developing effective management of podoconiosis. Again the government should focus on those who are poor and uneducated living in podoconiosis endemic areas for the success of podoconiosis management. Inter sectoral collaboration is a need for elimination of the diseases.

References

1. Molla, Y., *The spatial epidemilogy of podoconiosis in northern Ethiopia*. 2014, University of Brighton.
2. Price, E., *The association of endemic elephantiasis of the lower legs in East Africa with soil derived from volcanic rocks.* Transactions of the Royal Society of Tropical Medicine and Hygiene, 1976. **70**(4): p. 288-295.
3. Davey, G., *Podoconiosis: let Ethiopia lead the way.* The Ethiopian Journal of Health Development (EJHD), 2016. **22**(1).
4. Birrie, H., F. Balcha, and L. Jemaneh, *Elephantiasis in Pawe settlement area: podoconiosis or bancroftian filariasis?* Ethiopian medical journal, 1997. **35**(4): p. 245-250.
5. Destas, K., M. Ashine, and G. Davey, *Prevalence of podoconiosis (endemic non-filarial elephantiasis) in Wolaitta, Southern Ethiopia.* Tropical Doctor, 2003. **33**(4): p. 217-220.
6. Onapa, A.W., P.E. Simonsen, and E.M. Pedersen, *Non-filarial elephantiasis in the Mt. Elgon area (Kapchorwa District) of Uganda.* Acta Tropica, 2001. **78**(2): p. 171-176.
7. Ruiz, L., E. Campo, and M. Corachan, *Elephantiasis in Sao Tome and Principe.* Acta tropica, 1994. **57**(1): p. 29-34.
8. Tada, M. and P. Marsden, *Probable podoconiosis in Brasilia.* Revista da Sociedade Brasileira de Medicina Tropical, 1993. **26**(4): p. 255-255.
9. Wanji, S., et al., *Elephantiasis of non-filarial origin (podoconiosis) in the highlands of north–western Cameroon.* Annals of Tropical Medicine & Parasitology, 2008. **102**(6): p. 529-540.
10. Davey, G. and M. Newport, *Podoconiosis: the most neglected tropical disease?* The Lancet, 2007. **369**(9565): p. 888-889.
11. Kassaye, K.D., *Mapping of the spatial distribution and epidemiology of podoconiosis in Ethiopia : implications for diseases control.* 2016.
12. Tekola Ayele, F., et al., *HLA class II locus and susceptibility to podoconiosis.* New England Journal of Medicine, 2012. **366**(13): p. 1200-1208.
13. Tekola, F., et al., *Development and testing of a de novo clinical staging system for podoconiosis (endemic non-filarial elephantiasis).* Tropical Medicine & International Health, 2008. **13**(10): p. 1277-1283.
14. Price, E.W., *Podoconiosis: non-filarial elephantiasis*. 1990: Oxford University Press.
15. WHO, *Diseases covered by NTD Department, Book Diseases covered by NTD Department.* 2011.
16. Alemu, G., et al., *Burden of podoconiosis in poor rural communities in Gulliso woreda, West Ethiopia.* PLoS neglected tropical diseases, 2011. **5**(6): p. e1184.
17. Geshere Oli, G., F. Tekola Ayele, and B. Petros, *Parasitological, serological and clinical evidence for high prevalence of podoconiosis (non-filarial elephantiasis) in Midakegn district, central Ethiopia.* Tropical Medicine & International Health, 2012. **17**(6): p. 722-726.
18. Kloos, H., A.B. Kello, and A. Addus, *Podoconiosis (endemic non-filarial elephantiasis) in two resettlement schemes in western Ethiopia.* Tropical Doctor, 1992. **22**(3): p. 109-112.
19. Molla, Y.B., et al., *Podoconiosis in East and west gojam zones, northern ethiopia.* PLoS neglected tropical diseases, 2012. **6**(7): p. e1744.
20. Tekola Ayele, F., et al., *Community-based survey of podoconiosis in Bedele Zuria woreda, west Ethiopia.* International health, 2013. **5**(2): p. 119-125.
21. Davey, G., *Podoconiosis, non-filarial elephantiasis, and lymphology.* Lymphology, 2010. **43**(4): p. 168-177.
22. Tekola, F., D.H. Mariam, and G. Davey, *Economic costs of endemic non-filarial elephantiasis in Wolaita Zone, Ethiopia.* Tropical Medicine & International Health, 2006. **11**(7): p. 1136-1144.

23. Yakob, B., K. Deribe, and G. Davey, *Health professionals' attitudes and misconceptions regarding podoconiosis: potential impact on integration of care in southern Ethiopia.* Transactions of the Royal Society of Tropical Medicine and Hygiene, 2010. **104**(1): p. 42-47.
24. Hotez, P.J., *Stigma: the stealth weapon of the NTD.* PLoS neglected tropical diseases, 2008. **2**(4): p. e230.
25. Perera, M., et al., *Neglected patients with a neglected disease? A qualitative study of lymphatic filariasis.* PLoS neglected tropical diseases, 2007. **1**(2): p. e128.
26. Tora, A., G. Davey, and G. Tadele, *A qualitative study on stigma and coping strategies of patients with podoconiosis in Wolaita zone, Southern Ethiopia.* International Health, 2011. **3**(3): p. 176-181.
27. Yakob, B., K. Deribe, and G. Davey, *High levels of misconceptions and stigma in a community highly endemic for podoconiosis in southern Ethiopia.* Transactions of the Royal Society of Tropical Medicine and Hygiene, 2008. **102**(5): p. 439-444.
28. GebreHanna, E., *The social burden of podoconiosis and familial occurrence in its development.* MPH Thesis, Addis Ababa University, Ethiopia, 2005.
29. Weiss, M.G., *Stigma and the social burden of neglected tropical diseases.* PLoS neglected tropical diseases, 2008. **2**(5): p. e237.
30. Susman, R.L., *Evolution of the human foot: evidence from Plio-Pleistocene hominids.* Foot & ankle, 1983. **3**(6): p. 365-376.
31. Wood, B. and B.G. Richmond, *Human evolution: taxonomy and paleobiology.* The Journal of Anatomy, 2000. **197**(1): p. 19-60.
32. Wang, W. and R. Crompton, *Analysis of the human and ape foot during bipedal standing with implications for the evolution of the foot.* Journal of biomechanics, 2004. **37**(12): p. 1831-1836.
33. Saltzman, C.L. and D.A. Nawoczenski, *Complexities of foot architecture as a base of support.* Journal of Orthopaedic & Sports Physical Therapy, 1995. **21**(6): p. 354-360.
34. Cubukcu, S., et al., *Plantar arch type and strength profile of the major ankle muscle groups: A morphometric-isokinetic study.* Isokinetics and exercise science, 2005. **13**(3): p. 217-222.
35. Magee, D.J., *Orthopedic physical assessment-E-Book*. 2014: Elsevier Health Sciences.
36. Morag, E. and P. Cavanagh, *Structural and functional predictors of regional peak pressures under the foot during walking.* Journal of biomechanics, 1999. **32**(4): p. 359-370.
37. Williams Iii, D.S., I.S. McClay, and J. Hamill, *Arch structure and injury patterns in runners.* Clinical biomechanics, 2001. **16**(4): p. 341-347.
38. Sachithanandam, V. and B. Joseph, *The influence of footwear on the prevalence of flat foot. A survey of 1846 skeletally mature persons.* Bone & Joint Journal, 1995. **77**(2): p. 254-257.
39. Dunn, J., et al., *Prevalence of foot and ankle conditions in a multiethnic community sample of older adults.* American journal of epidemiology, 2004. **159**(5): p. 491-498.
40. Burns, J., et al., *Interventions for the prevention and treatment of pes cavus.* The Cochrane Library, 2007.
41. Mann, R.A. and F. Thompson, *Rupture of the posterior tibial tendon causing flat foot. Surgical treatment.* The Journal of bone and joint surgery. American volume, 1985. **67**(4): p. 556-561.
42. Coughlin MJM, R.A., *Surgery of the foot and ankle.* St. Louis, MO: Mosby, 1999: p. 772–773.
43. Sangeorzan, B.J., V. Mosca, and S.T. Hansen Jr, *Effect of calcaneal lengthening on relationships among the hindfoot, midfoot, and forefoot.* Foot & ankle, 1993. **14**(3): p. 136-141.
44. Redmond, A.C., Y.Z. Crane, and H.B. Menz, *Normative values for the foot posture index.* Journal of Foot and Ankle research, 2008. **1**(1): p. 6.
45. Redmond, A.C., J. Crosbie, and R.A. Ouvrier, *Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index.* Clinical Biomechanics, 2006. **21**(1): p. 89-98.

46. Hunt, A.E. and R.M. Smith, *Mechanics and control of the flat versus normal foot during the stance phase of walking.* Clinical biomechanics, 2004. **19**(4): p. 391-397.
47. Murley, G.S., et al., *Effect of foot posture, foot orthoses and footwear on lower limb muscle activity during walking and running: a systematic review.* Gait & posture, 2009. **29**(2): p. 172-187.
48. VanderHave, K.L., R.N. Hensinger, and B.W. King, *Flexible cavovarus foot in children and adolescents.* Foot and ankle clinics, 2013. **18**(4): p. 715-726.
49. Keenan, M.A., et al., *Valgus deformities of the feet and characteristics of gait in patients who have rheumatoid arthritis.* Journal of Bone and Joint Surgery-Series A, 1991. **73**(2): p. 237-247.
50. Lopez, A.D., et al., *Global burden of disease and risk factors. Washington, DC: World Bank.* Disease Control Priorities Project, 2006.
51. Animut, A., *The burden of non-filarial elephantiasis in Ethiopia.* Transactions of the Royal Society of Tropical Medicine and Hygiene, 2007. **101**(12): p. 1173-1174.
52. FMOH, 2011.
53. Davey, G. and E. Burridge, *Community-based control of a neglected tropical disease: the mossy foot treatment and prevention association.* PLoS neglected tropical diseases, 2009. **3**(5): p. e424.
54. Mousley, E., et al., *The impact of podoconiosis on quality of life in Northern Ethiopia.* Health and quality of life outcomes, 2013. **11**(1): p. 122.
55. YB, M., *The spatial epidemiology of podoconiosis in northern ethiopia PhD thesis report.* 2014.
56. Gwani, A.S., et al., *Normal values of foot arch parameters in adult Hausa population of Nigeria.* Journal of Experimental and Clinical Anatomy, 2016. **15**(2): p. 90.
57. Nilsson, M.K., et al., *Classification of the height and flexibility of the medial longitudinal arch of the foot.* Journal of foot and ankle research, 2012. **5**(1): p. 3.
58. Murley, G.S., H.B. Menz, and K.B. Landorf, *A protocol for classifying normal-and flat-arched foot posture for research studies using clinical and radiographic measurements.* Journal of foot and ankle research, 2009. **2**(1): p. 22.
59. Redmond, A., *The Foot Posture Index: user guide and manual.* Retrieved September, 2005. **29**: p. 2014.
60. Habtu, A., *Ethnic federalism in Ethiopia: background, present conditions and future prospects.* 2003.

Appendix1: Informed consent

ADDIS ABABA UNIVERSITY, COLLEGE OF HEALTH SCIENCES ,
SCHOOL OF MEDICINE, DEPARTMENT OF MEDICAL ANATOMY
INFORMED CONSENT

Investigator : Yikeber Argachew Deml(BSc, MSc candidate)

Thesis title: ***association between foot type and podoconiosis and other individual covariates of podoconiosis:comparative cross-sectional study ,Dembecha ,North west ,Ethiopia , 2017.***

I*ntroduction*: You are *kindly invited to participate in a study* title aforementioned above. The main focus of this proposed study is to determine the relationship of ***foot type and podoconiosis and other individual covariates of podoconiosis.*** This study will contributes to plan in line with research results to prevent and control podoconiosis.

Phases of the study:-two phases namely: ***at community level and hospital level***

Required for:**- you are required** to give answers for some questions about your general health, lifestyle and socio-demographic characteristics. Your height, weight, leg length and leg breadth will be measured. You will be asked to be examined non-invasive clinical examination only for five minutes. There is also very little risk digital lateral angular x-ray of the foot.

All information that you give and the results from you will be used for this study only. Only limited number of professionals will have access to the information.

The study *may not directly benefit you*, but you have the right to know your results which will be identified by code.

Your participation is exclusively voluntary and you have the right to refuse your participation in this study. You can stop to participate in the study at any time after giving your assent. If you Withdraw from the study, the samples will be withdrawn from analysis.

For any questions you may encounter during this study you can contact directly to:

Yikeber Argachew Deml.

Mobile: +251 -0932-819-461

Email: yikeber_argachewy@yahoo.com

Assent: - Agree ☐ disagree ☐

Appendix 2 Questionnaire for assessment of individual level correlates of podoconiosis

A. Socio-demographic details (head of household and patients)

NO	Question	Answer	Skip
A01	Age		
A02	Sex		
A03	Educational status?	1. No education 2. Informal 3. Primary 4. Secondary 5. Higher	
A04	What is your occupation?	1. Farmer 2. Housewife 3. Potter 4. Weaver 5. Merchant 6. Daily laborer 7.employed 8. unemployed	
A05	What is your religion?	1. Orthodox 2. Muslim 3. Protestant 4. Catholic 5. Other (specify)_____	
A06	What is your ethnicity?	1. Amhara 2. Oromo 3. Wolaita 4. Sidama 5. Gurage 6. Gamo 7. Tigre	
A07	Residence	1.Urban 2. Rural	
A08	What was your first language	1. Amharegna 2. Oromegna 3. Wolaitegna 4. Sidamagna 5. Guragegna 6. Gamogna 7. Tigregna 8. Other (specify):_____	
A9	What is your current marital status?	1. Single/never married 2. Married 3. Divorced 4. Widowed	
A10	What is your average monthly income (in *Birr*)?	1. _____ Birr	
A11	Do you live in this *Kebele* throughout the year?	1. Yes 2. No	If 'Yes' skip

			to **B01**
A12	How many months do you spend out of this *Kebele*?		
A13	Where did you go?	Explain_____	
A14	When did you go?	Explain_____	

B. Antropometry

No	Questions	Answer	skip
B01	Weight	_____kg	
B02	Height	_____cm	
B03	Foot length	_____cm	
B04	Foot breadth	_____cm	
B05	Body mass index	_____kg/m2	

C. Use of Shoes

NO	Question	Answer	skip
C01	Have you ever owned a pair of shoes?	1. Yes 2. No	
C02	How old were you when you first owned a pair of shoes?	____ Years	
C03	How many of the years since this have you had a pair of shoes?	1. All the years. 2. Almost all the years. 3. More than half of the years. 4. About half of the years. 5. Less than half of the years. 6. Almost none of the years. 7. None of the years.	
C04	When you own a pair of shoes, how often do you use them?	1. Every day. 2. More than 5 days per week. 3. 2-5 days per week. 4. Every week, but less than 2 days per week. 5. Less often than weekly.	
C05	On a shoe-wearing day, how much of the day do you wear shoes?	1. All day. 2. More than half the day. 3. About half the day. 4. Less than half the day. 5. Only a few hours.	
C06	For which of these activities do you wear shoes? (multiple answers possible)	1. Walking to market 2. Going to church 3. Attending a funeral 4. *Kebele* meeting 5. Attending a wedding 6. Ploughing	

		7. Planting 8. Harvesting 9. Work inside the house 10. Fetching water	
C07	For which of these activities you **do not** wear shoes? (multiple answers possible)	1. Walking to market 2. Going to church 3. Attending a funeral 4. *Kebele* meeting 5. Attending a wedding 6. Ploughing 7. Planting 8. Harvesting 9. Work inside the house 10. Fetching water	
C08	Do you own a pair of shoes right now?	1. Yes 2. No	If 'No' skip to**C12**
C09	How many pairs of shoes do you have?	_____ Pairs	
C10	How many pairs of shoes do you need/year?	_____ Pairs	
C11	What type of shoes do you have? (multiple answers possible)	1. Sandals – plastic 2. Sandals – tyre/'*berbaso*'/ '*gilet'* 3. Closed shoes – plastic 4. Closed shoes – foam/EVA 5. Closed shoes – leather 6. Canvas/ '*shera'*	
C12	OBSERVE: What kind of shoe the interviewee is wearing at the time of interview?	1. Sandals – plastic 2. Sandals – tyre/'*berbaso*'/ '*gilet'* 3. Closed shoes – plastic 4. Closed shoes – foam/EVA 5. Closed shoes – leather 6. Canvas/ '*shera'* 7. Barefooted	

D. Washing feet

No	Question	Answer	Skip
D01	Can you get enough water to wash your feet?	1. Yes 2. No	If Yes' skip to **D03**
D02	What is the problem?	1. Seasonal shortage 2. Distance 3. Other (specify):_____	
D03	Did you wash your feet last night?	1. Yes 2. No	
D04	How many times/week do you wash your feet?	_____times	
D05	Do you use soap for your feet?	1. Yes 2. No	If 'No' skip to **D07**
D06	How many times/week do you wash your feet with soap?	_____times	
D07	OBSERVE: Are the interviewee's feet clean?	1. Clean and intact 2. Dirty 3. Cracked 4. Dirty and cracked	

E. Distances walked

NO	Question	Answer	Skip
E01	How many minutes' walk is your nearest field? (1 way)	___ minutes	
E02	How many times do you walk to your nearest field each month?	___ times	
E03	How many minutes' walk is your furthest field? (1 way)	___ minutes	
E04	How many times do you walk to your furthest field each month?	___ times	
E05	How many minutes' walk is your regular market? (1 way)	___ minutes	
E06	How many times do you walk to market each month?	___ times	
E07	What is the source of your water?	1. Pipe 2. Well 3. Stream/river 4. Spring 5. Other _____	
E08	How many minutes' walk is this water source? (1 way)	_____minutes	

E09	How many times do you walk to this water source each month?	_____ times			
E10	Do you walk to other places for work purposes?	1. Yes 2. No			f 'No' skip to **E12**
E11	Record activity, minutes walked and frequency per month	Activity	Minutes (1way)	Frequency	
E12	Do you walk to other places for social purposes?	1. Yes 2. No			If 'No' skip to **F 1**
E13	Record activity, minutes walked and frequency per month	Activity	Minutes (1 way)	Frequency	
E14	Which road do you usually use when you go out of your house?	1. On the paved way 2. In between the ploughed field			
E15	Do you usually travel on foot or use animals?	1. On foot 2. Using animals (horse or donkey)			
E16	How much of your time do you spend on farming activities?	_____months			
E17	How much of your time is spend on ploughing?	_____months			
E18	How much of your time is spend on harvesting?	_____months			
E19	How much of your time is spend on removing weeds?	_____months			

F. Podoconiosis patients only

No	Question	Answer		Skip
F01	How old were you when you first noticed your legs were swollen?	___ Years		
F02	How old were you when you first tried to get treatment?	___ Years		
F03	How many years passed until your legs became as they are now?	___ Years		
F04	Does anyone else in your family have swollen legs?	1. Yes 2. No		If 'No', skip to **F05**
F05	Which family member(s) is/are affected?	Family	Number	
		Grandmother		

		Grandfather		
		Uncle		
		Aunt		
		Father		
		Mother		
		Brother		
		Sister		
		Cousin		
		Son		
		Daughter		
		Grandson		
		Granddaughter		
F06	Has your leg ever suddenly become hot, red and painful?	1. Yes 2. No		If 'No', skip to **F08**
F07	How often does your leg become hot, red and painful?	1. Every week 2. Every two weeks 3. Every month 4. Every 3 months 5. Every 6 months 6. Every year 7. Less often than every year		
F08	How long do you have to stop working when your leg is hot, red and painful?	___ days		
F09	Under which weather conditions do you experience the most problems with your leg(s)	1. Hot and dry season 2. Hot and wet season 3. Cold and dry season 4. Cold and wet season 5. No difference by season		

G.Clinical assessment I

RIGHT LEG	**LEFT LEG**
G01. Which leg is swollen? 1.Right 2.Left 3. Both	

G02 Staging Right (1-Sage I, 2-Stage -II,3,4,5) Left ()			
G01 Stage (1-5)	1 2 3 4 5	1 2 3 4 5	G01 Stage (1-5)
G02 Moss	1. Yes 2. No	1. Yes 2. No	G02 Moss
G03 Circumference (cm)			G03 Circumference (cm)
G04 Wound	1. Yes 2. No	1. Yes 2. No	G04 Wound
G05 Type	1. Water bag 2. Nodular 3. Mixed	1. Water bag 2. Nodular 3. Mixed	G05 Type
G06 Inguinal nodes	1. Normal 2. Enlarged	1. Normal 2. Enlarged	G06 Inguinal nodes
G07 Signs of ALA	1. Yes 2. No	1. Yes 2. No	G07 Signs of ALA

H. Clinical assessment II for individuals who have no history of podoconiosis (only filled by trained anatomist)

No	Foot posture index -six	Score	Total
H01	Talar head palpation		
H02	Supra and infra lateral malleolar Curvature		
H03	Calcaneal frontal plane position		
H04	Prominence in the region of the talonavicular joint		
H05	congruence of the MLA		
H06	Abduction /adduction of the fore foot on the rear foot		
Total			

I. Digital x-ray measurement (Lateral & AP) of foot arch (for right foot) taken only by radiologist or trained radiographer

NO	Question	Answer	Skip
I01	Navicular height (NH)	_____cm	
I02	First cuneiform height (FCH)	_____cm	
I03	Cuboid height (CIA)	_____cm	
I04	Calcaneal-fifth metatarsal angle (C5MA)	_____°	
I05	calcaneal inclination angle (CIA)	_____°	
I06	Calcaneal first metatarsal angle (C1MA)	_____°	
I07	Talo-navicular coverage angle (TNCA)	_____°	
I08	talus-second metatarsal angle (T2MA)	_____°	
I09	Intermetatarsal Angle	_____°	

We have finished the interview. Thank you for your time and participation!
Interviewer: Provide health education and soap now