NORMAL PERIPHERAL ARTERIAL PARAMETERS IN YOUNG HEALTHY BLACK AFRICANS IN TANZANIA

TUNTUFYEGE ERASTO MWASANJOBE, MD

MSc PHYSIOLOGY DISSERTATION

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

October 2021

Muhimbili University of Health and Allied Sciences

Department of Physiology

NORMAL PERIPHERAL ARTERIAL PARAMETERS IN YOUNG HEALTHY BLACK AFRICANS IN TANZANIA

By

Tuntufyege Erasto Mwasanjobe

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Physiology of the Muhimbili University of Health and Allied Sciences

October 2021

CERTIFICATION

The undersigned certifies that he has read and hereby recommend for acceptance by the Muhimbili University of Health and Allied Sciences a dissertation entitled **"Normal peripheral arterial parameter in young healthy black Africans in Tanzania"** in partial fulfillment of the requirements for the degree of Master of Science in Physiology at Muhimbili University of Health and Allied Sciences**.**

……

Dr**.** Fredirick Mashili (MD, PHD)

Supervisor

……

……

Dr. Omary Chillo (MD, PHD)

Co Supervisor

…….

……

Dr. Ashabilan Ebrahim (MD, MSc)

Co-Supervisor

……

DECLARATION AND COPYRIGHT

I TUNTUFYEGE ERASTO MWASANJOBE, declare that this dissertation is my original work and that it has not been presented and will not be presented to any other university for a similar or any other degree award.

Signature…… Date……..

ACKNOWLEDGEMENT

I would like to thank all those who made this dissertation possible and complete it in different ways.
First and foremost, I thank the powerful Almighty GOD for the gift of life and protection throughout my studies and research to me and those who made this dissertation possible.

I would like to thank my family, my wife, my mother, children, and brothers and sisters for their prayers and tolerance for the whole period of the studies and dissertation.

I sincerely express my gratitude to my employer, the District Executive Director, and the District Medical Officer of Magu District Council for the permission to come to pursue this course.
As well as to my sponsor from Tandabui Institute of Health Sciences and Technology under the Kingdom Business Limited for the financial support.

I extend my thanks to my supervisor Dr. Frederick Mashili and my co-supervisor Dr. Omary Chillo and Dr. Ashabillan Ebrahim for their guidance in the completion of this dissertation.

I would like to thank my research assistant Mr. Temba and Mr. Kapinda for their tireless working spirit throughout the data collection period.

Deep down in my heart, I would like to thank the first-year undergraduate students who participated in this study, by giving up their time, despite being in a tight study schedule.

DEDICATION

To my family, my wife Eunicke Lupilya Mboje, my mother Christina Mwasanjobe, and my children Abraham Tuntufyege, Queeniel Tuntufyege, Dorcas Tuntufyege, and Bright Tuntufyege.

ABSTRACT

Background: Functionally arteries play the role of supplying blood, oxygen, and nutrients to the peripheral tissues and organs to maintain normal physiological state. Compromised arterial function as a result of atherosclerosis may cause progressive arterial narrowing and eventually blockage. Routine peripheral arterial function (PAF) is primarily assessed by the Ankle Brachial Index (ABI) and can provide information on arterial status. Other parameters include, Toe Brachial Index (TBI) and Pulse Volume Waveform (PVW), both with internationally established reference values for normal and impaired arterial status.

Several reports have shown discrepancies between the established ABI, TBI, and PVW normal reference values, with values obtained from different populations of healthy, disease-free individuals. Despite the availability of noninvasive peripheral arterial test (using ABI, TBI, and PVW) to assess PAF, and the increasing prevalence of peripheral arterial diseases (pad) assessment of PAF is not commonly done in our setup. Furthermore, data comparing ABI, TBI, and PVW from young PAD-free black Africans with internationally established reference values, are lacking. Due to this, we aimed to determine ABI, TBI, and PVW in a population of young, healthy, and PAD-free black Africans and compare the results with internationally established normal reference values.

OBJECTIVE: To determine normal peripheral arterial parameters (ABI, TBI, and PVW) and compare with internationally established references, in young and healthy black Africans.

Methodology: A cross-sectional study was conducted among first-year undergraduate students from Muhimbili University of Health and Allied Sciences (MUHAS). A total of 121 students volunteered to participate in the study (minimum 104). Data was collected using a standardized questionnaire for demographics, medical history and lifestyle, and other risk factors. We used an automated device to measure ABI, TBI, and PVW and compared the obtained value with the American Heart Association (AHA) reference. Anthropometric (height, body mass index (BMI), and waist to hip ratio (WHR) and cardiac (blood pressure (BP) and resting pulse rate (RPR)) parameters were measured and their effect on Peripheral Arterial Status/ parameters was elucidated using multiple linear regression. Data were expressed as mean ± standard deviation

(SD), and as a median in interquartile ranges (IQR) for continuous and in frequency table for categorical data, respectively. Student t-test used to determine the difference between means and P-value of < 0.05 are considered statistically significant.

Results

A total of 121 undergraduate first-year students with a median age of 20(20,23IQR), were recruited. All maintained a relatively healthy lifestyle (fruit and vegetable intake and physical activity level of >600MET/min/week. They had a median body mass index of 21.5(19.72, 23.46 IQR) and all had no obvious symptoms and signs suggestive of PAD. Majority of study participants who met inclusion criteria had normal peripheral arterial parameters (ABI (81% right, 52.9%left), TBI (75.2% right, 66.1%left) and PVR (>86% toe,>96% ankle)).We found a significantly higher seated brachial blood pressure on the right when compared with the left (P <0.001). Likewise, a significantly higher Ankle Brachial Index (ABI) was found on the right side (1.06±0.08 right vs. 1.00±0.09 left) (P<0.0001). The overall mean Toe Brachial Index (TBI) was 0.77±0.11 and 0.74±0.14 on the right and left respectively, and did not differ significantly between the two sides. In general, males had higher brachial blood pressures and ABI than females. When compared to the AHA normal reference range the values for the lower limits of our population's 95%confidence interval (right ABI =0.9 and left ABI=0.82) fell below the reference range (ABI=1.00-1.3)

Conclusion and Recommendation

Despite comparable values between our population mean ABI and TBI with that of AHA, interpretation of right and left ABI in healthy young black Africans, using established cut-offs should be done with caution**,** given the relatively lower values on the left. In addition, based on the findings of ABI and TBI being lower than established standards (AHA) for normal in apparently healthy young adults, lower values for ABI and TBI might not necessarily mean abnormalities in this age group. Further research to clarify these findings and confirm whether the lower limit of normal references in a population of healthy young adults should be lowered, is warranted.

Table of Contents

CERTIFICATION ii
DECLARATION AND COPYRIGHT iii
ACKNOWLEDGEMENT iv
DEDICATION v
ABSTRACT vi
LIST OF TABLES xi
LIST OF FIGURES xii
LIST OF ABRIVIATION xiii
DEFINITION OF TERMS xv
CHAPTER ONE ..... - 1 -
1.0 INTRODUCTION ..... - 1 -
1.1 Background ..... - 1 -
1.2 Problem of statement ..... - 4 -
1.3 Rationale ..... - 5 -
1.4 Physiological model ..... - 5 -
1.5 Conceptual framework ..... - 6 -
1.6 Research questions ..... - 7 -
1.7 Objective ..... - 7 -
CHAPTER TWO ..... - 8 -
2.0 LITERATURE REVIEW ..... - 8 -
2.1 INTRODUCTION ..... - 8 -
2.2 Determination of ABI, TBI, and PVWs in young healthy black Tanzanian ..... - 9 -
2.3 Comparison ABI, TBI, and PVW in young healthy black Tanzanians with internationally established references for normal arterial status ..... - 11 -
2.4 Comparison of ABI, TBI, and PVW between young healthy males and female black Tanzanians ..... - 12 -
CHAPTER THREE ..... - 14 -
3.0 RESEARCH METHODOLOGY ..... - 14 -

3.1 Study design ..... - 14 -
3.2 Study area and setting ..... - 14 -
3.3 Study population ..... - 14 -
3.4 Inclusion criteria ..... - 14 -
3.5 Exclusion criteria ..... - 14 -
3.6 Sample size ..... - 16 -
3.7 Sample selection ..... - 17 -
3.8 Variables ..... - 18 -
3.9 Data management ..... - 19 -
3.10 Validity and reliability ..... - 21 -
3.11 Data analysis ..... - 22 -
3.12 Ethical issues ..... - 22 -
CHAPTER FOUR ..... - 23 -
4.0 RESULTS ..... - 23 -
4.1 Demographic and clinical characteristics ..... - 23 -
4.2 Determination of ABI, TBI, and PVWs ..... - 25 -
4.3 Comparison between the observed ABI and TBI international established Range ..... - 30 -
4.4 Comparison of ABI, TBI, and PVWs between Young healthy males and females ..... - 33 -
4.5 Factors Affecting ABI and TBI ..... - 34 -
CHAPTER FIVE ..... - 36 -
5.0 DISCUSSIONS ..... - 36 -
5.1 Ankle Brachial Index and Toe Brachial Index ..... - 36 -
5.2 Ankle Brachial Index and Toe Brachial Index between male and female ..... - 37 -
5.3 Factors Affecting Ankle Brachial Index and Toe Brachial Index ..... - 38 -
5.4 Pulse Volume Waveforms (PVWs) ..... - 38 -
CHAPTER SIX ..... - 39 -
6.0 CONCLUSION AND RECOMMENDATION ..... - 39 -
6.1 STRENGTH OF THE STUDY ..... - 39 -
6.2 LIMITATION ON THE STUDY ..... - 39 -
REFERENCES ..... - 40 -

APPENDICES: ..... - 49 -
APPENDIX 1: INFORMED CONSENT FORM-ENGLISH VERSION ..... - 49 -
KIAMBATISHO II. FOMU YA OMBI LA RIDHAA -KISWAHILI ..... - 52 -
APPENDIX III: QUESTIONNAIRE ENGLISH VERSION ..... - 55 -
KIAMBATISHO IV: DODOSO 64
APPENDEX V: ETHICAL CLEARANCE 71
APPENDIX VI: INTRODUCTION LETTER 73

LIST OF TABLES

Table 1: Family Socio and demographic characteristics of the study participants ..... - 24 -

Table 2: Clinical characteristics of the study participants ..... - 25 -

Table 3: Comparison between right and left Ankle Brachial Index (ABI) and Toe Brachial Index (TBI) ..... - 27 -

Table 4: Comparison between right and left leg Ankle Brachial Index (ABI) and Toe Brachial Index (TBI) ..... - 28 -

Table 5:Pulse Volume Waveforms (PVWs) ..... - 29 -

Table 6:The difference in mean ABI and TBI between male and female ..... - 33 -

Table 7:Estimated regression coefficients from the multiple linear regression models to predict ABI and TBI ..... - 35 -

LIST OF FIGURES

Figure 1: Overlap between Coronary Artery Disease (CAD), Cerebrovascular Disease (CVD) and Peripheral Arterial Disease (PAD) Adopted from Bhatt DL, et al REACH Investigation, presented at American College of Cardiology Annual Scientific session march 8, 2005: Orlando, Abstract 1127.96..... - 4 -

Figure 2: Physiological model..... - 5 -

Figure 3: Conceptual framework..... - 6 -

Figure 4: Interpretation of pulse volume waveforms based on four levels grading system. - 18 -

Figure 5: Showing data collection process from the 156 potentially healthy undergraduates first-year students of MUHAS, 121 met the inclusion criteria were voluntarily recruited .. - 20 -

Figure 6: Showing the comparison between the observed ABI normal range and American Heart Association normal reference range of ABI 1.00 to 1.3. ..... - 30 -

Figure 7: Showing the comparison between observed normal TBI and American Heart Association cut-off. ..... - 31 -

Figure 8:(a) Show reference Waveform from and interpretation (b) Waveform from one of the study subjects having similar features as compared to the reference. ..... - 32 -

LIST OF ABRIVIATION

ABI	Ankle Brachial Index
ACC	American College of Cardiology
AHA	American Heart Association
ART	Anti-Retroviral Therapy
BMI	Body Mass Index
BP	Blood Pressure
CAD	Coronary Arterial Disease
CVD	Cardiovascular Disease
DM	Diabetes Mellitus
DPA	Dorsalis Pedis Artery
ES	Effect Size
ESC	European Society of Cardiology
FVFS	First Volunteer First Select
HIC	High Income Countries
HTN	Hypertension
IHD	Ischemic Heart Disease
LMIC	Lower- and Middle-Income Countries
LP (a)	Lipoprotein a
MESA	Multi-Ethnic Study Atherosclerosis
MNH	Muhimbili National Hospital
MoHCDEC	Ministry of Health, Community Development, Elderly and Children
MUHAS	Muhimbili University of Health and Allied Sciences
NCD	Non-Communicable Disease
PAD	Peripheral Arterial Disease
PPAD	Premature Peripheral Arterial Disease
PTA	Posterior Tibia Artery
PVWs	Pulse Volume Waveforms
SPSS	Statistical Package for the Social Sciences

SSA	Sub Saharan Africa
WHO	World Health Organization
WHR	Waist to Hip Ratio
WIC	Written Informed Consent
TIHEST	Tandabui Institute of Health Sciences and Technology
PAPs	Peripheral Arterial Parameters
PAF	Peripheral Arterial Function

DEFINITION OF TERMS

Peripheral arterial function (PAF)-is the ability of peripheral arteries (such as abdominal aorta, iliac and lower extremity arteries) to supply blood ,oxygen, and nutrient to the peripheral organs in a steady state blood flow(1,2).

Peripheral Arterial Disease (PAD) - is a vascular disease characterized by narrowing or blockage of arteries supplying the lower limb due to atherosclerosis and diagnosed mainly by Ankle Brachial Index (ABI) of ≤0.9 and other parameters are Toe Brachial Index (TBI) ≤0.7 and Pulse Volume Waveforms (PVWs) ≥ Grade B(3).

Peripheral Arterial Parameters (PAP) - are measurable factors used to assess peripheral arterial function/status and diagnose PAD(1). In this study ABI, TBI and PVWs will be used to assess the status of young healthy black Africans in Tanzania

Ankle Brachial Index (ABI) -Defined as the ratio of the Systolic Blood Pressure at the ankle (Posterior Tibia Artery - PTA /Dorsalis Pedis Artery-DPA) to the higher of the Systolic Blood Pressure at the brachial of either right or left (3,4).

Toe Brachial Index (TBI)–Defined as the ratio of toe blood pressure to the brachial blood pressure and used to assess and diagnose Peripheral Arterial Disease (3)

Pulse Volume Waveforms (PVW)–Are Pulse volume recordings (PVR) used to assess peripheral arterial status by measuring arterial blood flow in blood vessels (arteries) in the leg or arms. The waveforms are characterized in a four-level grading system (A-normal, B-mild PAD, C-moderate PAD, and D-Severe PAD) (5).

Young Adult - will be defined as age in years from 15 years to 34 years (6)

Obesity- is defined as the Body Mass Index greater or equal to 30 kg/m^2(7)

Overweight - is the Body Mass Index between 25 to 29.9 Kg/m^2(7)

Abdominal /Central Obesity is defined as a waist circumference of ≥ 90 cm in men and ≥80cm in women and a Waist to Hip Ratio (WHR) ≥of 0.95 for males and ≥0.86 for females(7).

Hypertension (HTN) - will be defined as Systolic Blood Pressure greater or equal to 140mmhg and diastolic Blood Pressure greater or equal to 90mmhg or on antihypertensive(8)

Diabetes Mellitus (DM) - will be defined as fasting blood glucose ≥7.0 mmol/l (126mg/dl) or random blood glucose ≥11.1mmol/l (200mg/dl) on ant diabetic(9)

History of smoking - defined as any action of ever inhaling and exhaling burnt plant materials such as tobacco products and marijuana in form of cigarette, cigar, or pipe(10)

Physical activity- refers to any activity that can increase heart rate and respiratory rate, and is performed continuously for at least 10 minutes. Can be categorized into three levels as vigorous, moderate, and sedentary(11)

Alcohol drinking- is the consumption of beverages containing ethyl ethanol

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The primary function of arteries is to supply blood, oxygen, and nutrients to the peripheral tissues and organs(2). This is important, generally to maintain body functioning and homeostasis (12).Peripheral arteries, which supply the lower limbs are equally important and substantially contribute to the overall functioning of arteries(1,2). Therefore, proper arterial functions is attained when the peripheral arteries function normally.

Several factors (commonly atherosclerosis) may compromise arterial function and cause progressive arterial narrowing, that if left unchecked may lead to blockage(3). Atherosclerosis affects peripheral arterial function and may cause peripheral arterial disease (PAD). Patho-physiologically PAD starts early (at a young age) and is triggered by modifiable and non-modifiable risk factors that are common causes of most cardiovascular diseases(CVD)(13–15). Also, peripheral arterial function changes with aging, making the assessment of PAF across the lifespan crucial. Given the importance of assessment of PAF, tools and parameters that can be used as routine measures of PAF need to be explored.

Peripheral arterial parameters (PAPs) are measurable factors used to assess the peripheral arterial status/function and diagnose Peripheral Arterial Disease (PAD)(1). These parameters measure blood flow in arterial blood vessels invasively or non-invasively (1,3). The invasive method includes Angiography Computed Tomography (CT) and Magnetic Resonance Imaging (MRI)(1,3). The non-invasive method includes Segmental arterial blood pressure (Ankle Brachial Index-ABI and Toe Brachial Index-TBI), Doppler ultrasound waveform which is the gold standard, and Pulse Volume Recording(PVR)(1,3). Noninvasive methods (ABI, TBI, and PVW) are cost-effective, and simple, hence preferred for initial assessment of PAF and screening for PAD (3,16).while invasive is reserved for confirmation of noninvasive before surgical intervention(3). Invasive bear significant risk (such as bleeding, infection, allergy and nephropathy) throughout the procedure, involves blood vessel puncture and administration of

contrast dye(17,18). A good example is contrast angiography. Also are cost full, time consuming and expertise(3).

ABI, TBI, and PVW are mainly used to assess the larger peripheral arteries (abdominal aorta, iliac and lower extremity arteries)(18,19). These parameters can be measured manually by using a sphygmomanometer, Doppler, and photoplethysmography (PPG) or automatically using automated oscillometric devices(16). Since 1990s automated device have been in use and proved to simple, cheap, accurate and reproduce results as the gold standard, Doppler ultrasound(16,20). Furthermore overcome the intraobserver variability is that exist in manual assessment of PAF(16,21)**.**

Despite the epidemiological shift of PAD from high-income countries (HIC) to lower and middle-income countries (LMIC) and the presence of noninvasive and simple methods, routine assessment of PAF and screening of PAD are not usually done in our populations(22,23). There is also paucity of data on the validity, reliability and general usability of simple PAF assessment parameters (ABI, TBI, PVR) in African populations. To date studies have been done in Africa and none in Tanzania, to evaluate normal peripheral arterial parameters (PAPs) (ABI, TBI, and PVW) in young healthy Africans(22)**.** Based on this, undertaking the objective assessment of peripheral arterial function even on seemingly healthy individuals was crucial (24). This will help to determine peripheral arterial status in different populations of healthy and asymptomatic people.

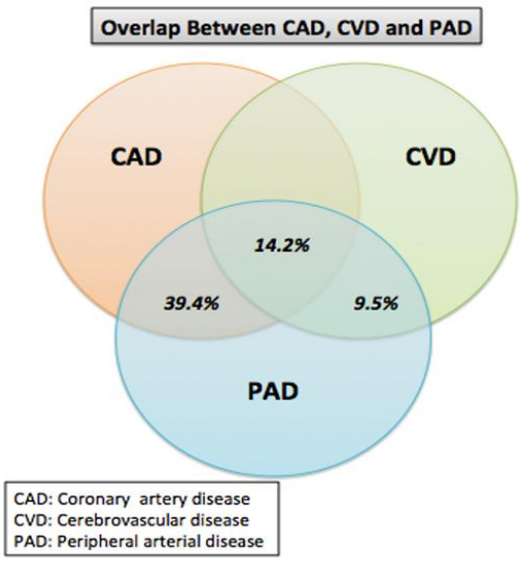
Peripheral arterial status can be assessed using an ankle-brachial index (ABI) which is the ratio of the ankle to brachial pressures (25,26). ABI is measured by computing ankle blood pressure dividing by higher of the two Brachial systolic BP, whereas an ABI of 1 to 1.3 is categorized as normal. An ABI of 0.91 to 0.99 is categorized as borderline and that of ≤0.9 is classified as abnormal, indicating PAD based on AHA (27). ABI has been validated using gold standard methods to assess peripheral arterial function and PAD and found to be accurate, reliable, and reproducible(28–31). Whether ABI obtained from PAD-free young black Africans reflects internationally established normal cut-offs, remains to be confirmed.

Toe brachial index (TBI) is more reliable in assessing peripheral arterial function, especially in calcified vessels as the cause of incompressibility (32). TBI is the ratio of toe pressure to brachial pressure**.** A TBI of >0.7 is considered normal and has been shown to predict both adverse events and mortality(32). However, this cut-off of 0.7 is still in question because of the technique used to measure, preheating limb before measurement tends to give a higher normal value for TBI(33,34). Peripheral arterial function/status can further be determined using pulse volume waveforms (PVW). PVW are analyzed based on their quality, shapes, and amplitude and classified as being normal or abnormal (PAD) based on defined standards(35,36). Similarly, whether internationally established TBI and PVW standards are reflected in healthy PAD-free black Africans, is a question for further research.

Advances in technology have led to the introduction of automated devices (oscillometric devices) that can simultaneously measure ABI, TBI, and PVW(21). Given their simplicity and easy operation, these devices have a lot of potential for use in a primary care setting in developing countries, where the expertise to perform Doppler studies are scarce. Determining ABI, TBI, and PVW in healthy young adults will provide peripheral arterial status in young healthy subjects. Further evaluation of how these key parameters are similar or deviate from the established cut-offs for normal arterial status, will provide valuable information and a local database for future studies involving both normal and individuals with PAD in African populations.

1.2 Problem of statement

Globally 236 million people aged 25 years and above are living with PAD. In the year 2015, 72.99% of adults from Lower- and Middle-income countries with predominance ages between 45-49 years, and 25-34years in Africa, were living with PAD (23). This reflects the epidemiological shift of PAD to LMIC where the disease affects relatively young age (22,23).



PAD share common modifiable risk factors with coronary artery diseases (CAD), and in most cases, the two diseases co-exist (33). Major risk factors include cigarette smoking, hyperlipidemia, hypertension, diabetes mellitus, and metabolic syndrome (34–37). Other modifiable risk factors are obesity, physical inactivity, an unhealthy diet, and alcohol intake (37, 38). Even though PAD is common in the elderly, most of the modifiable risk factors occur early in life.

Figure 1: Overlap between Coronary Artery Disease (CAD), Cerebrovascular Disease (CVD) and Peripheral Arterial Disease (PAD) Adopted from Bhatt DL, et al REACH Investigation, presented at American College of Cardiology Annual Scientific session march 8, 2005: Orlando, Abstract 1127.96

Lifestyle-related risk factors such as physical inactivity, unhealthy eating, alcohol intake, and cigarette smoking are common practices among urban-dwelling young adults, 18 to 45 years of age(37).

Despite the known association between PAD and cerebrovascular events(38), objective assessments of peripheral arterial function are not routinely performed. Furthermore, physiological determination of peripheral arterial function/status in normal populations has never been done in Tanzania. It is also uncertain whether the internationally established reference values for normal arterial status and PAD are reflected in healthy, PAD-free Tanzanians and those with PAD, respectively. Therefore, physiological studies involving young and healthy subjects are mandated.

1.3 Rationale

This study will provide a baseline of peripheral arterial status in normal subjects and show whether they are similar or deviate from internationally established normal reference values. The study proposed herewith, will be one of the early physiological studies to determine key physiological parameters based on internationally established references, in healthy and young black Tanzanians. Data from the proposed study will provide evidence as to whether the internationally defined and established normal ABI, TBI, and PVW are reflected in young healthy black Tanzanians. This will aid the appropriate categorization of peripheral arterial status and diagnosis of PAD in our local populations.

1.4 Physiological model

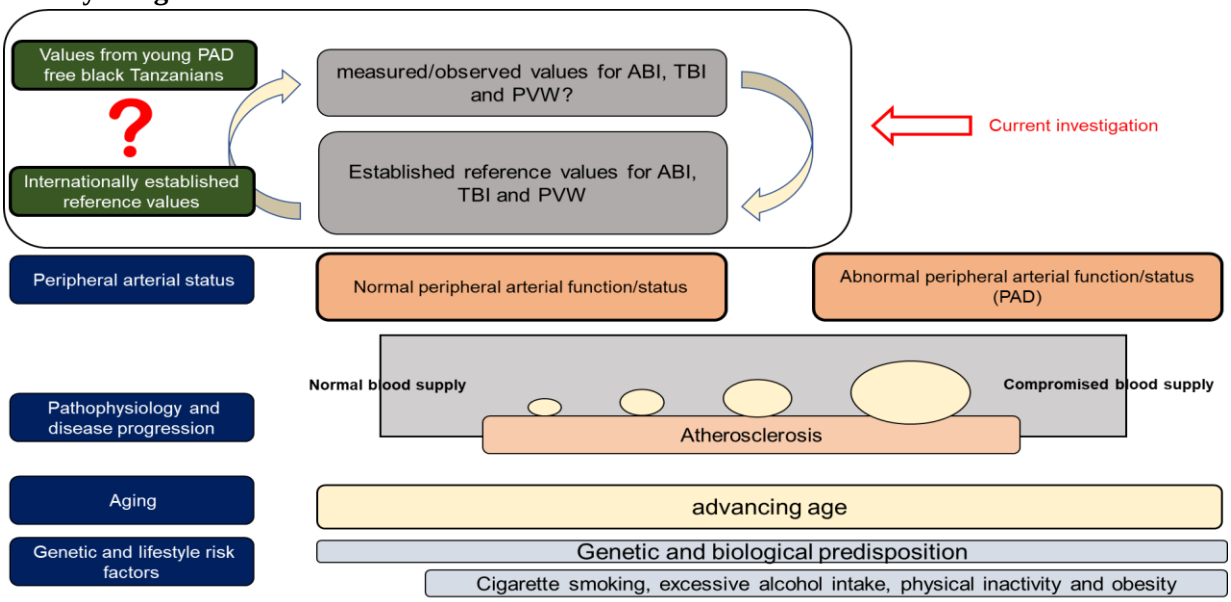


Figure 2: Physiological model

A physiological model portraying the link between PAD risk factors, age at onset, pathophysiology, disease progression and highlight the research question of whether key peripheral arterial parameters (ABI, TBI, and PVW) obtained from young PAD-free black Tanzanians will reflect internationally established references for normal peripheral arterial status.

1.5 Conceptual framework

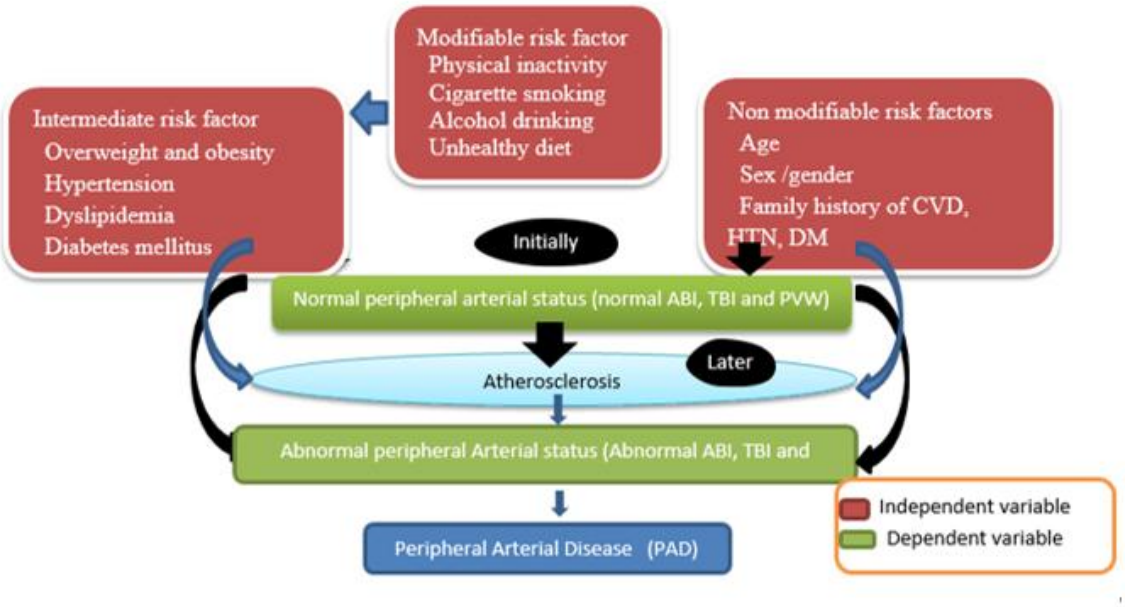


Figure 3: Conceptual framework

1.6 Research questions

Overall research question: Do peripheral Arterial parameters (ABI, TBI, and PVWs) in young black Tanzanian reflect those of internationally established references?

1. What is the status of Peripheral Arterial Function (ABI, TBI, and PVW) in young, healthy black Tanzanians?
2. Do ABI, TBI, and PVW from young healthy Tanzanians, the same as, or deviate from internationally established normal reference values for normal arterial status?
3. Do ABI, TBI, and PVW significantly differ between young, healthy males and females?

1.7 Objective

1.7.1 Broad objective

To determine normal peripheral arterial parameters (ABI, TBI, and PVW) based on internationally established references, in a population of young and healthy black Tanzanians.

1.7.2 Specific objectives

1. To determine the normal value status of ABI**,** TBI, and PVW in young healthy black Tanzanians.
2. To compare the normal value of ABI, TBI, and PVW in young healthy black Tanzanians with internationally established references for normal arterial status.
3. To compare the normal value ABI, TBI, and PVW between young healthy, males and females.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

Peripheral Arterial function/status and PAD are assessed by several peripheral arterial parameters which can either be invasive or noninvasive (1,3). Segmental arterial blood pressure(mainly ABI and TBI), Doppler ultrasound, and PVR are the noninvasive methods(3). These measure blood flow in blood vessels to determine arterial function. Noninvasive methods are preferred by health professionals over invasive due to their simplicity, faster, cost-effectiveness, and less expertise need(20). Best used for initial assessment of peripheral arterial function and screening of PAD in primary health care(1). The computed tomography and magnetic resonance angiography are reserved for further assessment for PAD diagnosis and peripheral arterial status(3). Despite the presence of PAD epidemiological shift from HIC to LMIC and the availability of simple noninvasive methods to assess peripheral arterial function, few studies were done in young black Africans(22).

In a systematic review of studies on PAD, epidemiology and global perspective reported that, despite the evidence of an epidemiological shift of PAD from High-Income Countries (HIC) to low and Middle Income (LMIC), still very few studies have been done to determine the occurrence of PAD in low and middle-income settings(22). Also, a study by P. Song et al reported that 72.91% of 236 million people with PAD globally were from LMIC however in African PAD was noted at a young age between 25-34 years(23). The increase of cerebrovascular events (stroke) in young adults signifies the presence of asymptomatic PAD in this age group because of their co-existence (39). Further, physiological studies describing the status of peripheral arterial function in young adults are extremely limited in LMIC(22). This necessitates a great reliance on western studies done over the years, which might not necessarily reflect local conditions.

Given genetic and environmental differences between different populations in the world(40–42), data obtained elsewhere need to be validated in the local population before being applied locally. This also applies to validating internationally established references for defining normal

and disease states(43,44). Appropriate disease diagnosis to a large extent depends on the availability of reliable reference values for normal/healthy status upon which to base any deviation caused by diseases(43,44). Normal reference values are obtained from healthy, often disease-free populations, hence a need for physiological studies in healthy populations(43,44). Put together, these reasons and facts point to a need for research to define locally relevant physiological and pathophysiological reference values in health and disease, respectively.

2.2 Determination of ABI, TBI, and PVWs in young healthy black Tanzanian

The ankle-brachial index (ABI) is the ratio of the ankle to brachial pressures (25,26). ABI is obtained by computing ankle blood pressure dividing by higher of the two brachial systolic BP and was originally described by Winsor in the year 1950(4). Even though ABI was initially proposed for the non-invasive assessment of peripheral arterial function and diagnosis of PAD(45,46), a growing body of evidence later showed that the ABI may be used to indicate atherosclerosis at other vascular sites and predicts cardiovascular events(28–30). ABI can also be used as a prognostic marker of functional impairment even in those with asymptomatic PAD(38,47,48). ABI is also important in the assessment of leg ulcers and plays a role in classifying ulcers into venous arterial and mixed types(49)

Toe brachial index(TBI) is the ratio of toe pressure and brachial pressure and is calculated by taking toe blood pressure diving by the high brachial blood pressure(1). TBI is used to determine the function of the small blood vessels when ABI is found to be falsely high due to calcification in an asymptomatic individual. Furthermore, toe blood vessels are temperature sensitive and constrict in cold conditions giving false lower TBI(34). Therefore for reliable results of TBI stable room temperature need to be maintained and preheating limb technique may be employed as reported in a systematic review study by Hoyer et al(34). However regarding the cut-off and normal range for TBI, still there is no global agreement. Several studies from PAD-free reported different values of mean TBI where 0.81 by Watanabe et al, 0.97 males and 0.95 females by Quong et al,0.71 by Brooks et al,0.75 Muro et al. likewise for the ranges(20,33,34).

PAD is rare in young normal adults and difficult to diagnose(50). A data analysis study done in Japan among normal young adult students aged 20 to 25 years observing 1282 legs, reported mean ABI and TBI of 1.05 and 0.81 respectively, and the two standard deviation range reported to be 0.87-1.23 and 0.55-1.06 for ABI and TBI respectively(20). Also similar finding of mean ABI of 1.14 range (1.05-1.25) S.Male et al(51)**.** However ABI of ≤1.0 in 18.1% of legs in men and 25.6% leg in women, TBI of ≤0.7 was 16.2% in men toes and 19.1 in women(20). Another study detected ABI≤1.0 by 8% in men and 19% in women aged between 20 to 39 years. This may not tell exactly the presence of vascular dysfunction but indicate the ability of ABI to identify peripheral arterial status in young normal PAD-free adults with modifiable risk factors and normal serum makers(50,52). Since the used normal reference value for ABI and TBI were derived from older people which are not exactly reflected in the young needs to be researched.

Pulse volume waveforms (PVWs) which are very close to the Doppler ultrasound waveforms are used to further determine the peripheral arterial status(5). PVWs are analyzed based on their quality, shape, and amplitude. PVWs are amplified electrical signals of converted pulsatile pressure by a pressure transducer as blood flow underneath the cuff. Young adults reported having lower amplitude despite having normal waveform compared to adults by Watanabe et al(20)

2.2.1 Normal peripheral Arterial Parameters (ABI, TBI, and PVWs)

Despite the known ethnic and gender differences in ABI, popular internationally established ABI references (cut-off values) are commonly used to categorize normal arterial status. In Tanzania, where the ABI is usually not routinely done, there is still no consensus as to which criterion should be used to categorize peripheral arterial status and diagnose PAD. For that reason when ABI measurements are done, different people use different criteria to categorize peripheral arterial status. Often the American College of Cardiology (ACC)/American Heart Association (AHA) and the European Society of Cardiology (ESC) criteria are used. Even though other criteria may be used by others, the fore mentioned are the commonly used.

According to the ACC/AHA guidelines an ABI of ≤0.90, 0.91-0.99, and 1.00-1.40 are considered as abnormal (PAD), borderline and normal, respectively. The ABI greater than 1.40,

is also considered abnormal and is a result of uncompressible vessels(53). The European Society of Cardiology (ESC) has similar cutoff points with those of ACC/AHA except for a slight difference in classifying borderline status 0.90-1.0(54). Therefore, it is mostly referenced that a normal ABI is 1.0 or > 1.0, where a result of 0.9 or less indicates some degree of arterial disease(PAD)(46,54). For TBI even though studies show no consensus about the cut-off of, based on the ACCF/AHA TBI of >0.7 is regarded as normal(34). However other studies take TBI of 0.6 as a normal cut-off and the lower limit normal range of 0.49-0.74(34). Normal PVWs as interpreted by Runwell and McPharnlin based on shapes must have brisk systolic upstroke, sharp systolic peak, gradual down, and dicrotic notch, as well as amplitude and quality(5,55).

2.2.2 Factors affecting Peripheral Arterial Parameters

Peripheral arterial parameters variations can be caused by physiological changes and pathological conditions. Physiologically ABI tends to increase with age and height due to vascular changes such as walking vertically and stiffening with advanced age and amplification of blood pressure waves travel distally respectively(20,51,56). Brachial blood pressure has a negative correlation with ABI, as BP increases ABI decreases(51). Other factors are sex and ethnicity where being female and black is associated with lower ABI(57). Furthermore is affected by exercise tend to be lower just after exercise and normalize after five to ten minutes(57).

TBI is temperature sensitive and prone to vasoconstriction thus, tends to vary proportionally with temperature(34). This is well explained when the preheating of the limb before measurement of toe pressure produces a higher value of TBI compared to non-preheated(33,34).TBI as ABI is also affected by sex, age, and height(20).

Despite being very close to the gold standard, Doppler ultrasound waveforms, PVWs are varied with age where young present with low amplitude as compared with adults(20)**.**

2.3 Comparison ABI, TBI, and PVW in young healthy black Tanzanians with internationally established references for normal arterial status

In addition, multiethnic studies have consistently reported lower ABI values for blacks when compared to Hispanics and whites in the USA(58–67). Despite the differences, normal values

for all ethnicities still fall within the internationally established references (cut-offs) for normal arterial status and PAD. It is however known that most of the studies used to derive the established reference values were done in relatively older populations(58–67).

Studies comparing ABI measured from populations of young healthy adults and that from established reference values are scarce, a few studies have re-assessed ABI and TBI based on established references. Coull and Murphy-Black reported ABI values ranging from 1.05 to 1.25 with a mean value of 1.14, in a population of Australian young adults(51). Despite being within the established normal range, the observed mean (1.14) was significantly higher than the reference (51). Similarly, Quong et al reported significantly higher toe brachial index (TBI) values (when compared to published and established reference value of <0.7 for normal arterial status) in healthy, young adult Canadians(33). This implies that reference values for normal arterial status should possibly be presented as ranges and not means to avoid misclassifying peripheral arterial status in young adults. In any case, whether established reference values (literally derived from studies conducted in relatively older populations) are reflected in healthy young adults from different populations is a question of further investigation.

2.4 Comparison of ABI, TBI, and PVW between young healthy males and female black Tanzanians

Despite the established and popularly used reference values (cut-offs), ethnic and sex differences do exist, the knowledge of which is important in interpreting ABI results(58–67). Several studies have reported significant differences between males and females with females having slightly lower ABI values than males(56,61–64). In the Multi-Ethnic Study of Atherosclerosis (MESA) females had about 0.02 lower ABI values than males. (62)A slightly higher difference between males and females was observed in the San Luis Valley Diabetes study where females had 0.07 lower ABI values relative to males(59). Several other studies have reported lower ABI values in females when compared to males concluding that intrinsic factors are possibly responsible for the ABI differences observed between males and females(61–64) (56).

Nevertheless, some authors investigating sex differences among young adults have reported no significant difference in ABI values between the two sex and others have reported even higher ABI in females(68). Sex difference in other parameters used to determine peripheral arterial status, TBI reported to slightly lower in female and variable as compared to males which were 0.95 and 0.97 respectively(33). Similarly, Watanabe et al reported a difference of 0.01in the young population(20). Furthermore, several studies have reported TBI to be consistently insignificant higher in males, and no study was done in our setting to validate the existence of difference**.** Sex difference in PVWs is still inconclusive and demands further investigations(51).

Put together, the variability in ABI and TBI caused by various physiological, genetic, and environmental factors, sex and ethnicity, call for investigations to explore these parameters among Tanzanians. With the ongoing epidemiological shift in PAD to LIMC and young adults, baseline determination of key parameters used to define peripheral arterial status is timely and mandated. Even though internationally established reference values are used, until recently Tanzania lack consensus on which guidelines and references to use. This study will initiate the evaluation of peripheral arterial parameters based on internationally established references in young PAD-free black Tanzanian.

The study will take advantage of an automated device (Smartdop, XT, Kodymedics, India) to simultaneously measure and evaluate ABI, TBI, and PVW and compare the results with established reference values for normal arterial status.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Study design

This was a community-based prospective cross-sectional study to determine the normal peripheral arterial parameter in young healthy black Africans in Tanzania.

3.2 Study area and setting

The study was conducted at the Muhimbili University of Health and Allied Sciences (MUHAS**)** among undergraduate students. The University admitted around a total of 775 undergraduate first-year students in the academic year 2020/2021. Of those admitted 603 (77.8 %) and 175 (22.2%) were males and females respectively, with predominant ages between 20 -25. This gave us a relatively homogenous sample of young adult males and females who had less diversity on various factors affecting peripheral arterial function/status. This was important to ensure internal validity. This study area was also selected as the students can be followed over time as they proceed with their studies during which their age and lifestyle will be changing. In addition, since MUHAS admits students each year, a large sample of young adults will eventually be reached for future studies, and the pooled data can be analyzed and used to make more generalized inferences (external validity).

3.3 Study population

Young adults of first-year undergraduate students at MUHAS, who met all the inclusion criteria and consented to participate in the study.

3.4 Inclusion criteria

All young adults, potentially PAD-free (based on symptoms), males and females aged 18 to 35 years

3.5 Exclusion criteria

1. Known PAD patients
2. Known smokers
3. Known patients with hypertension.

4. Obvious symptoms and signs of PAD and vascular diseases (intermittent claudication, resting pain, and leg ulcers)
5. Those on medication that can affect blood pressure and ABI.
6. Individuals with obesity (BMI≥30)
7. Individuals with high WHR (≥0.95 male and 0.86 female)
8. Known diabetic patients.
9. Persons with orthopedic surgery with an internal or external fixator,
10. Persons with limb deformity or any physical deformity (shortening of one limb)

3.5.1 Justification for use of exclusion criterion as proxy (gold standard) contrast angiogram

Contrast angiogram is an invasive technique that involves blood vessel puncture and administration of contrast dye then followed by X-rays exposure to assess peripheral arterial function. Despite being the gold standard, it bears significant risk and complication to the participant during preparation, during the test, and after the test (such as bleeding, infection hematoma, atheroembolism, contrast allergy, and contrast-induced nephropathy) (17,18). Also is expensive, time-consuming, and requires trained and experienced personnel(3,17). Based on our study where normal young healthy adult participants were recruited, this would be unethical to expose the normal person to avoidable risk. However, several studies to find the normal value of ABI and TBI used exclusion criteria and non-invasive methods to get the potentially PAD-free participants. The study by S male et al used exclusion criterion to obtain a sample with PAD free in a preliminary study to investigate the normal range of ABI in young adults (51). Therefore, in our study, the setup of exclusion criteria and the questionnaire could greatly exclude volunteers with PAD and get those with PAD free participants and, eventually prevent a participant from contrast angiography-related risk and complications. The study used exclusion criteria to exclude participants with signs and symptoms of PAD

3.6 Sample size

To avoid statistically significant results for a trivial effect size, a small sample size with enough power to make reasonable inferences was desirable. For that reason, a power calculation was used to calculate the sample size. Using ABI as a primary outcome measure the observed ABI was compared with a reference cut-off (ABI=0.99)(69). Assumed the measured mean ABI to be 1.1 and allowed for a wide range of variability (SD=0.2) and significance at the level of 0.05(69,70). To achieve a power of 80%, a minimum of 52 (52X2=104 (male and female, plus 10% non-response 114, max 120) volunteers were needed. From this, we aimed to recruit a maximum of 120 young adults

The formula below was used to calculate the sample size.

$$n = \left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{ES} \right)^2$$

Where α is the selected level of significance and Z 1-α /2 is the value from the standard normal distribution holding 1- α/2 below it.1-β is the selected power and β is the type II error.

The ES is the effect size which was calculated using the formula.

$$\textbf{Effect Size} = ES = \frac{|\mu_1 - \mu_0|}{\sigma}$$

Where: - ES=Effect size, µ1=mean (1.1) 1, µ0=mean (0.99) 2, σ =standard deviation

3.6.1 Justification for small sample size

The need to detect a small effect size (ES) and avoid statistically significant differences for a small ES.

Due to the robustness of the assessments, this first physiological study on peripheral arterial function in Tanzania aimed to assess peripheral arterial function using ABI, TBI, and PVW and compare the results with known and established international reference values (cut-offs) that define normal arterial status.

A small sample size was appropriate since a large sample size may show significant deviation even when the deviation/the effect size is exceedingly small(71–73). This study focuses on ES which was the difference between the mean ABI and TBI (for continuous and PVW for categorical variables) between young, healthy subjects and internationally established normal reference values. Since ES was not affected by sample size as the p-value, a small sample size did not affect the results, and only a large ES was significant. With this sample size, a statistically significant difference from internationally established references suggested more study to assess the arterial status of young healthy black Africans, before deciding which references to use for young adults.

3.7 Sample selection

Convenient sampling, on a volunteering basis, was employed. The sampling frame was determined as all the first-year undergraduate students at MUHAS (775). The announcement was made verbally and in writing in the class to request the students to participate in the study. Inclusion criteria were set forth for those who wish to participate and the First volunteer first selected (FVFS) concept was used. Eligible volunteers who agree to participate were informed about the study then signed the consent form. **S**creened for inclusion and exclusion criteria during the survey that was conducted before the assessments. Then, the demographic and lifestyle questionnaires were administered to all participants before any assessment was done. Following the survey, anthropometric and physical assessments were as performed, where further exclusion criteria were applied. Eligible persons were identified enrolled in the study and peripheral arterial parameters measurement was performed.

The participant was allowed to withdraw from the study at any time he/she chooses to. This did not deny or affect the participant's right to counseling.

3.7.1 Justification to obtain potentially PAD free participants

The study population chosen (Young health adults) had a rare incidence of PAD this reduced the chance of obtaining participants with PAD (50). Careful screening using the exclusion criteria with a wide range of coverage excluded participants with PAD. Also, further screening was done using the questionnaire for the risk factor, claudication (Edinburgh questionnaire), and

anthropometric measurement was used to exclude those with signs and symptoms of PAD. On top of that after the assessment, those who fell beyond the two standard deviations (2SD) and with extreme value (out layers) were excluded from the analysis, because of a probable bearing chance of asymptomatic PAD or another peripheral vascular disease.

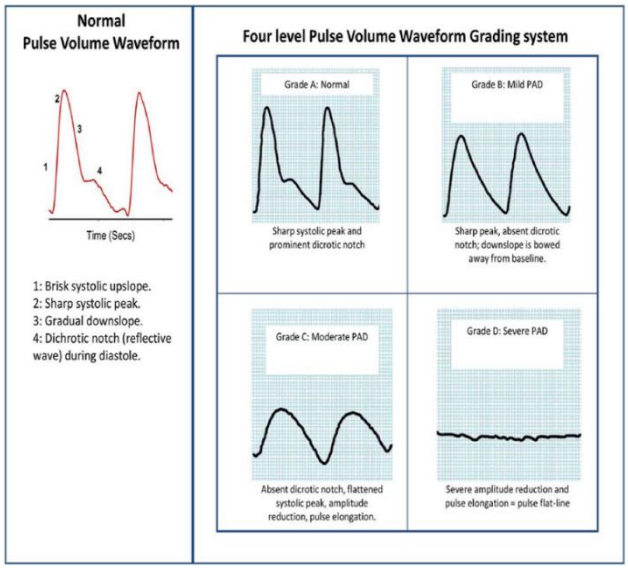
In this study, the American College of Cardiology/American Heart Association (ACC/AHA) normal range of 1.0 to 1.3 for Ankle Brachial Index (ABI) was used as international reference values

3.8 Variables

3.8.1 Dependent variable

Ankle Brachial Index, Toe Brachial Index, and Pulse Volume Waveforms

The primary (main) dependent variable was Ankle Brachial Index (ABI) which was used to assess peripheral arterial status. Since the main aim was to compare the results with established references for normal arterial status, therefore the homogeneous and as normal as the possible sample was selected. This was made possible by excluding individuals with most of the risk factors of PAD. In this regard the main independent variables were biological (sex, blood pressure, age, BMI, and WHR). Others were physical activity and lifestyle (diet, smoking, and alcohol intake).



Other dependent variables were pulse volume waveform (PVW) and Toe Brachial Index (TBI) which were also used to assess peripheral arterial function/status. Waveforms were interpreted and a four-level pulse wave grading system was used to define PAD (see figure below). A TBI of ≥0.7 was considered normal, while a TBI of <0.7 was considered abnormal.

Figure 4: Interpretation of pulse volume waveforms based on four levels grading system

3.8.2 Independent variable

The independent variables were: Age, sex, Blood pressure, BMI and WHR

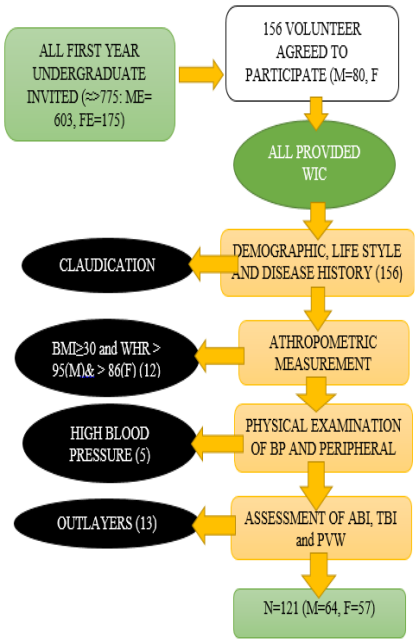
3.9 Data management

3.9.1 Data collection and methods

Two lab technicians as research assistants were recruited and trained for two days on how to perform the measurement, data collection, and recording.

A pilot study was done involving 12 participants, 10% of the sample size. The participants were obtained by voluntary sampling method. The announcement was made verbally in the class to request for volunteers to participate in the pilot study. Those agreed to participate were screened for inclusion and exclusion criterion. Eligible volunteers who agreed to participate were informed about the study and requested to sign the consent form. The First Volunteer First select (FVFS) concept was used till the sample was reached. A Questionnaire was administered by interviewing the participants by the research assistant and researcher. During this period the tools were tested and proved to collect the information required to respond to the research questions.

3.9.2 DATA COLLECTION PROCESS



156 potentially healthy undergraduate first year student of MUHAS, who met the inclusion criteria were voluntarily recruited from 10th May 2021 to 4th June 2021.The selected eligible volunteers for participation in the study were asked to sign the consent form after being informed about the study. Data were collected by interview using open ended structured questionnaire which captured social demographic and risk factors which were administered by researcher and trained research assistants. This had questions for age, sex, and history of smoking, Cardiovascular Disease, Diabetic Mellitus and Hypertension. Fruits and vegetable intake (79). Whereas a physical activity questionnaire by WHO and the Edinburgh claudication Questionnaire for physical activity and claudication were adopted respectively and used by trained interviewer without making changes(11,58,80). Also the questionnaire had detailed for physical measurement for height, weight, WC, HC resting heart rate and blood pressure. This process exclude 12 participants.

Figure 5: Showing data collection process from the 156 potentially healthy undergraduates first-year students of MUHAS, 121 met the inclusion criteria were voluntarily recruited

3.9.3 Collection tools

3.9.3.1 Anthropometric measurement

Height (m) was measured using a Stadiometer. This had a rigid vertical surface with attached scale in centimeter, and a horizontal mobile surface at a right angle, which slide freely vertically along the scale. The lower surface lies on the floor at the 0-centimeter scale. The study participant was instructed to stand straight as possible without shoes, where the heel, buttock, and head are in contact with the vertical surface, the head facing forward. The height was measured by sliding the mobile horizontal surface to the head of the participant and recorded in centimeters (cm). Also weight in kilograms (Kg) was measured by a calibrated balanced weighing scale placed on the flat surface, the participant was instructed to stand with their feet together and arm on the side of the body. The participant was required to remove shoes or any material that will affect the actual weight. Body Mass Index (BMI) was calculated by taking weight in kilograms (Kg) divide by height in meter squire (m^2). Then BMI of ≥40 very obese, 30-39.9 obese 25 to 29.9 overweight, 18.5 to 24.9 normal, and ≤ 18.5 underweight (7). Waist circumference (WC) in centimeters (cm) was measured two fingers above the umbilicus and Hip circumference (HC) in centimeters (cm) were both measured using a flexible inelastic tape measure. The Waist to Hip Ratio was calculated by taking Waist measurement (cm) divide by Hip measurement (cm) to determine central obesity where WC ≥90cm for males and ≥80cm in females and WHR of ≥0.90 in males and ≥0.85 in females

GENDER	WAIST TO HIP RATIO			
	Excellent	Good	Moderate	At-risk
Male	≤ 0.85	0.85-0.89	0.90-0.95	>0.95
Female	<0.75	0.75-0.79	0.80-0.86	>0.86

(7,74).

3.9.3.2 Blood pressure measurement

The blood pressure and heart rate were measured in the same room, which the temperature was maintained at 23^0C-24^0C throughout the data collection. All participants in sitting position were

rested for a minimum of five (5minutes) minutes then blood pressure and heart rate were measured in both arms and recorded on the datasheet. The Omron automatic blood pressure monitor, (model: M2 Basic HEM-7120-E) was used for all the participants. This automated device was able to measure both brachial blood pressure and heart rate at the same time. The cuff was wrapped on the arm two centimeters above the cubical and the measurement was taken. The first reading was recorded if was normal and if beyond the normal range the second reading was taken after two minutes of resting. This offered the chance to further exclude those with high measured Blood Pressure to participate in the study.

3.9.3.3 Peripheral arterial status assessment

Trained staff conducted and recorded in data sheet the BP measurement after 5 minutes of rest. At the same room temperature maintained at 23^0C-24^0C. All participants were rested in the supine position for a minimum of 5 minutes before peripheral arterial status assessment. The participants remained supine, quietly rested for the entire time of measurements. The cuffs were wrapped 2 cm above the cubical and 2 inches above the malleolus for brachial and ankle pressure respectively. For the toe, a cuff of about 2.5 cm wide was wrapped and Photoplethysmography (PPG) was applied on the great toe with the sensor in contact with the participant's skin. All cuffs and PPG were connected to an automated oscillometric device (Smartdop, XT, Kodymedics, India), which has six blood pressure cuffs and photoplethysmography. The device was able to measure bilateral Brachial Blood Pressure, Ankle Blood Pressure, and Toe Blood Pressure and produce the PVWs simultaneously. In this study, the posterior tibia artery was used to measure the lower limb Blood Pressure. ABI and TBI were computed by dividing SBP on each limb by higher SBP in the arm based on the specific guideline. PAD was defined by ABI $\leq$0.9 and PVWs of $\geq$ grade B at least one lower limb or prior revascularization **surgery** for PAD.(5,55,75)

3.10 Validity and reliability

The automated oscillometric method has been suggested to be reliable and practical for measuring ABI, TBI, and PVWs in non-diabetics and found to have greater than 90% accuracy, sensitivity, and specificity when compared to the gold standard Doppler ultrasound (1,16). The automated oscillometric device the Smartdop Kodymedics made in India can measure ABI,

TBI, and PVWs at the same time. This device produces Pulse Volume Recordings very similar to the gold standard Spectral Doppler ultrasound, and the best of it is simple and reduces operator-generated errors and variability (55).

3.11 Data analysis

The collected data were processed analyzed using Microsoft Excel, and Statistical Package for social sciences version 23 – (SPSS-V 23). The Kolmogorov-Smirnov and Shapiro-Wilk test was used to determine the normality of data distribution. Descriptive results were expressed in frequency tables and mean ±SD or median in the interquartile range were used for continuous data and percent for categorical data. One sample t-test was used to find the difference between the observed normal mean and the established international normal mean for continuous data. The independent t-test was used to find the difference in mean between the right leg and left leg and between male and female (right leg of males and female and left leg of male and female). A chi-square test was used for the categorical variables. The multiple linear regression by entering method was used to find the predictor for normal Ankle Brachial Index and Toe Brachial Index. A P-value of 0.05 was regarded as statistically significant in finding the association (5,74).

3.12 Ethical issues

Ethical clearance was obtained from the Institutional Review Board of MUHAS (Appendix No V). Permission to conduct the study was provided by the MUHAS administration (Appendix No VI) and participants signed the informed consent form before being enrolled. All participants were interviewed to obtain their demographic data and risk factors. Then anthropometric measurement, blood pressure (ankle, Toe, and Brachial), and pulse waveforms were taken once (and second reading if the first was lower than recommended normal ranges) using an automated oscillometric device.

The Confidentiality of each participant was maintained by providing the identification number and all information stored in protected computer files. Where only authorized staff had access.

CHAPTER FOUR

4.0 RESULTS

4.1 Demographic and clinical characteristics

Of 156 undergraduate students that volunteered, 121 participants 64(52.9 %) male and 57(47.1 %) female met the inclusion criteria, were recruited and their data analyzed. The study participant had a median age of 20(20, 23 IQR). More than 84% had no family history of hypertension, Diabetes Mellitus or, cardiovascular disease, (94.2%) with no history of drinking alcohol. All the participants maintained healthy life having, a 100% fruit and vegetable intake and physical activity level of more than 600MET in minutes per week, which is the minimum recommended by the World Health Organization (WHO) for heath living. (Table 1). The Median Body Mass Index (BMI) and Waist to Hip Ratio (WHR) of 21.50 (19.72, 23.46 IQR) and 0.79(0.75, 0.82 IQR) respectively. Bilateral sitting Arm Blood Pressure means was systolic (118±12) diastolic (72±8), resting heart rate (72±11) for right and systolic (117±13), diastolic (74±8), heart rate (72±11). (Table2.)

Table 1: Family Socio and demographic characteristics of the study participants

Variable	Category	Frequency (n)	Percent (%)
Age group (years)	18 - 25	105	86.8
	26 - 35	16	13.2
Median age in years (IQR)		20 (20, 23)	
Sex	Male	64	52.9
	Female	57	47.1
Marital status	Single	114	94.2
	Married	7	5.8
1st degree relative with HTN	Yes	19	15.7
	No	102	84.3
1st degree relative with DM	Yes	14	11.6
	No	107	88.4
1st degree relative with CVD	Yes	8	6.6
	No	113	93.4
Alcohol intake	Yes	5	4.1
	No	116	95.9
Fruits and vegetable intake	Yes	121	100
	No	0	0
Fruit /vegetable intake	Every day	45/49	37.2/40.5
	sometimes	76/72	62.8/59.5
	Not	0	0
The Portion of fruit/vegetable intake	More than 5 portions per day	34/1	2.5/0.8
	3 to 5 portions per day	55/14	28.1/11.6
	Less than 3 portions per day	68/65	45.5/53.7
	Less than one portion per day	23/35	19/28.9
	Rarely eat	6/6	5/5
Physical activity in MET minutes per week	<600 MET	10	8.5
	>600 MET	107	91.5

Table 2: Clinical characteristics of the study participants

Variable	Category	Frequency (n)	Percent (%)
BMI (Kg/m^2)	Underweight	13	10.7
	Normal	94	77.7
	Overweight	14	11.6
Median BMI in Kg/m^2 (IQR)		21.50 (19.72, 23.46)	
Height (cm)	<150	3	2.5
	150.00-160.00	33	27.3
	160.01-170.00	60	49.6
	170+	20	20.7
Median Height in cm (IQR)		164.05(159,169.50)	
Waist to Hip Ratio (WHR)	Excellent	82	67.8
	Good	25	20.7
	Moderate	14	11.6
Median Waist to Hip Ratio (WHR) (IQR)		0.79 (0.75, 0.82)	
Right arm (Mean ± SD)	Resting **Pulse** rate (Beat/min)	72 (± 11)	
	Systolic BP(mmHg)	117 (± 11)	
	Diastolic BP (mmHg)	72 (± 8)	
Left arm (Mean ±SD)	Resting **Pulse** rate (Beat/min)	72 (± 11)	
	Systolic BP(mmHg)	117 (±12)	
	Diastolic BP (mmHg)	73 (± 7)	

4.2 Determination of ABI, TBI, and PVWs

4.2.1 Blood Pressures (Brachial, Ankle, and Toe)

The blood pressure readings were within the normal limits. The right ankle systolic blood pressure (ASBP) was statistically significantly higher than the left leg ($P < 0.001$, d.f =236) in the whole sample and even on sex category analysis male ($P<0.001$, d.f=120) and female ($P<0.001$, d.f=111). The overall right TSBP was higher than left but statistically insignificant both in the whole sample and sex category. (Table 3)

4.2.2 Ankle Brachial Index (ABI) and Toe Brachial Index (TBI)

The general mean Ankle Brachial Index (ABI) was found to be 1.06±0.08 right and 1.00±0.09 left for the whole sample. Whereby sex was male 1.06±0.07 (right), 0.99±0.08 (left) and female 1.07±0.09 (right), 1.07±0.09 (left). The right mean ABI was found to be statistically

significantly higher than the left ABI in the whole sample and when analyzed based on sex category (male and female). However we found that there is significant number of participant legs with ABI <1.00 23(19%) right and 57(47.1 %) left and < 0.9 2(1.7%) right and 15 (12.4 %) left. This was more in left than right for the overall sample. The same was observed between males and females being statistically significant. (Table 3 & 4)

The overall mean Toe Brachial Index (TBI) was 0.77±0.11 right, 0.74±0.14 left. The mean TBI was 0.79±0.11 right, 0.75±0.13 left in males and 0.75±0.11 right, 0.72±0.15 left in females. The right TBI was consistently higher than the left even when analyzed separately between males and females, this was not statistically significant. Also there is great number of participant legs with TBI <0.7 30(24.8%) right, 41(33.9%) left and <0.6 8(6.6%) right, 19(15.7%). A larger number was more on the left leg than the right leg. The same was observed between males and females. (Table 3 & 4 and Figure 6&7)

Table 3: Comparison between right and left Ankle Brachial Index (ABI) and Toe Brachial Index (TBI)

	Total (n= 121)Right		Total (n= 121) Left		
	Mean±SD	2SD range	Mean±SD	2SD range	P value
Brachial Blood Pressure (mmhg)	128±12	104-152	126±11	104-148	0.168 (df=239)
Resting heart Rate (bpm)	72±11	50-94	72±11	50-94	0.852 (df=237)
Ankle Blood Pressure (mmhg)	138±13	112-164	130±11	108-152	<0.0001 (df 236)
Toe Blood Pressure (mmhg)	100±18	68-132	96±19	60-132	0.056 (df=238)
ABI	1.06±0.08	0.9-1.22	1.00±0.09	0.82-1.18	<0.0001 (df=239)
ABI < 1	23(19.0)		57(47.1)		<0.0001
ABI < 0.9	2(1.7)		15(12.4)		0.002
TBI	0.77±0.11	0.55-0.99	0.74±0.14	0.46-1.02	0.069 (df=231)
TBI < 0.7	30(24.8)		41(33.9)		0.192
TBI < 0.6	8 (6.6)		19(15.7)		0.034

Two samples independent t-test
Chi-square test

Table 4: Comparison between right and left leg Ankle Brachial Index (ABI) and Toe Brachial Index (TBI)

	Male (n = 64)			Female (n = 57)		
	Right	**Left**	**P value**	**right**	**left**	**P value**
Brachial Blood Pressure (mmhg)	131±12	129±11	0.266 (df=125)	125±10	123±10	0.380 (df=111)
Resting heart Rate (bpm)	69±11	69±11	0.916 (df=125)	76±10	76±10	0.859 (df=109)
Ankle Blood Pressure (mmhg)	140±14	131±11	<0.0001 (df=120)	136±10	128±11	<0.0001 (df=111)
Toe Blood Pressure (mmhg)	105±18	99±18	0.080 (df=125)	95±16	92±20	0.326 (df=105)
ABI	1.06±0.07	0.99±0.08	<0.0001 (df=125)	1.07±0.09	1.01±0.09	0.001 (df=111)
ABI < 1	13(20.3)	35(54.7)		10(17.5)	22(38.6)	
ABI < 0.9	1(1.6)	9(14.1)		1(1.8)	6(10.5)	
TBI	0.79±0.11	0.75±0.13	0.107 (df=124)	0.75±0.11	0.72±0.15	0.326 (df=104)
TBI < 0.7	12 (18.8)	18(28.1)		18(31.6)	23(40.4)	
TBI < 0.6	3(4.7)	8(12.5)		5 (8.8)	11(19.3)	

Two samples independent t-test

Chi-square test

4.2.3 Pulse Volume Waveforms (PVWs)

In this study, we found that majority of participants had triphasic 105(86.8%) in both rights and left great toe. Whereby on ankle triphasic 117(96.7%) right, 118(97.5) left. The grading system grade A was 107(88.4%) for both right and left leg toe ,and for ankle grade A 117(96.7%)right, 118(97.5%)left. Grade A PVWs are considered normal and grade B mild abnormal. Two participants were found to have grade C on the toe all being male and non on the ankle. Despite having normal PVWs some had ABI< 1.00 and TBI 0.7, this signifies a lower normal value in young healthy black Africans. (Table .5).

Table 5:Pulse Volume Waveforms (PVWs)

	Total (n =121		**Male (n = 64)**		**Female (n = 57)**	
	Right	**Left**	**Right**	**Left**	**right**	**left**
Great Toe						
Triphasic	105(86.8)	105(86.8)	58(90.6)	57(89.1)	47(82.5)	48(84.2)
Biphasic	16(13.2)	16(13.2)	6(9.4)	7(10.9)	10(17.5)	9(15.8)
Monophasic	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0(0.0)	0 (0.0)
Grade A	107(88.4)	105(86.8)	59(92.2)	57(89.1)	48(84.2)	48(84.2)
Grade B	14(11.6)	14(11.6)	5(7.8)	5(7.8)	9(15.8)	9(15.8)
Grade C	0 (0.0)	2(1.7)	0 (0.0)	2(3.1)	0 (0.0)	0 (0.0)
Grade D	0 (0.0)	0(0.0)	00 (0.0)	0(0.0)	0 (0.0)	0 (0.0)
Ankle						
Triphasic	117(96.7)	118(97.5)	62(96.9)	63(98.4)	55(96.5)	55(96.5)
Biphasic	4(3.3)	3(2.5)	2(3.1)	1(1.6)	2(3.5)	3(3.5)
Monophasic	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Grade A	117(96.7)	118(97.5)	62(96.9)	63(98.4)	55(96.5)	55(96.5)
Grade B	4(3.3)	3(2.5)	2(3.1)	1(1.6)	2(3.5)	2(3.5)
Grade C	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Grade D	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

4.3 Comparison between the observed ABI and TBI international established Range

4.3.1 Comparison of observed ABI and AHA normal range

Using a visual comparison of a confidence interval, in this study, the obtained ABI in the 95% confidence Interval range was lower when compared to the AHA range of 1.00 to 1.3. The upper limit was found to be within the normal range while the lower limits found out the normal range of the AHA normal range. The left was lower compared to the right with a mean of nearly 1.00. Furthermore, there is overlapping between the observed normal range and the reference normal range of AHA as shown in (figure 6). This signifies that there is no difference between the two ranges, though the lower limit needs to be expanded to fit in the population of young healthy black Africans**.**

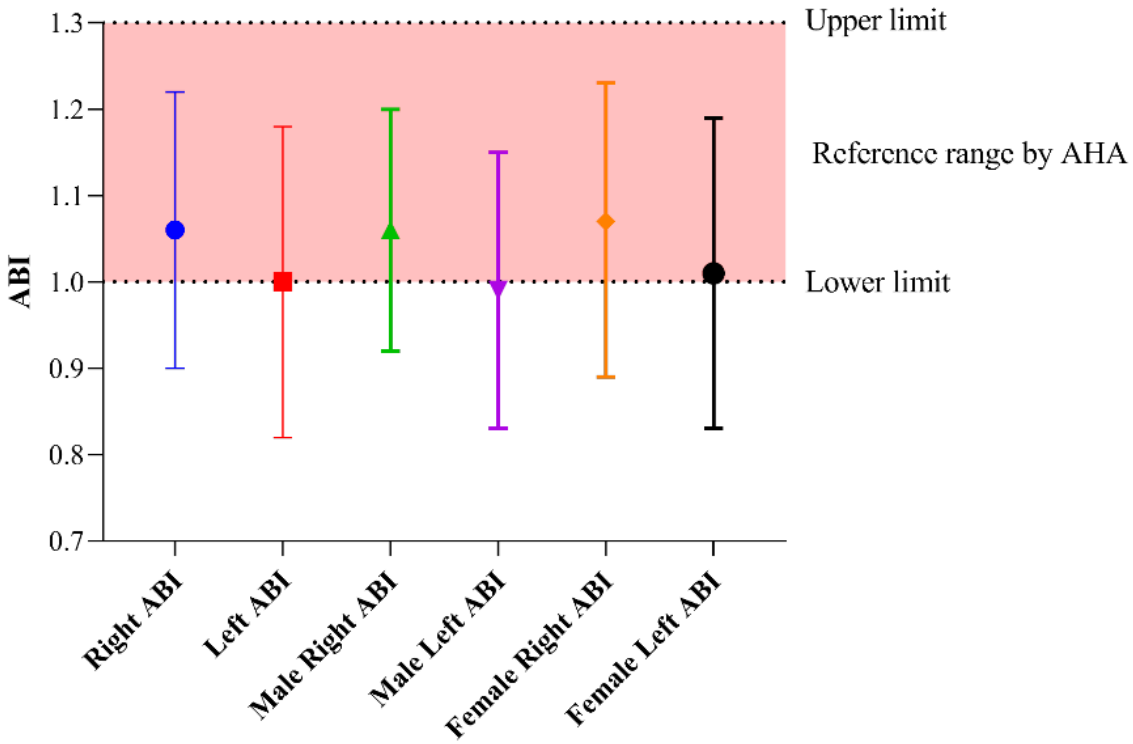


Figure 6: Showing the comparison between the observed ABI normal range and American Heart Association normal reference range of ABI 1.00 to 1.3.

4.3.2 Comparison between the observed Toe Brachial Index and American Heart Association normal Range

The obtained Toe Brachial index range in 95% confidence interval, when compared with American Heart Association cut-offs and ranges. We found that the mean TBI of both legs when analyzed in general and sex category fell above the normal cut-off of 0.7. The lower limits were found to fall below the cut-off value of 0.7, however, the left TBI value was consistently lower than the left. Furthermore, the presence of overlapping show no statistical difference between our obtained TBI with the established reference range of AHA and finding from other studies (figure 7).

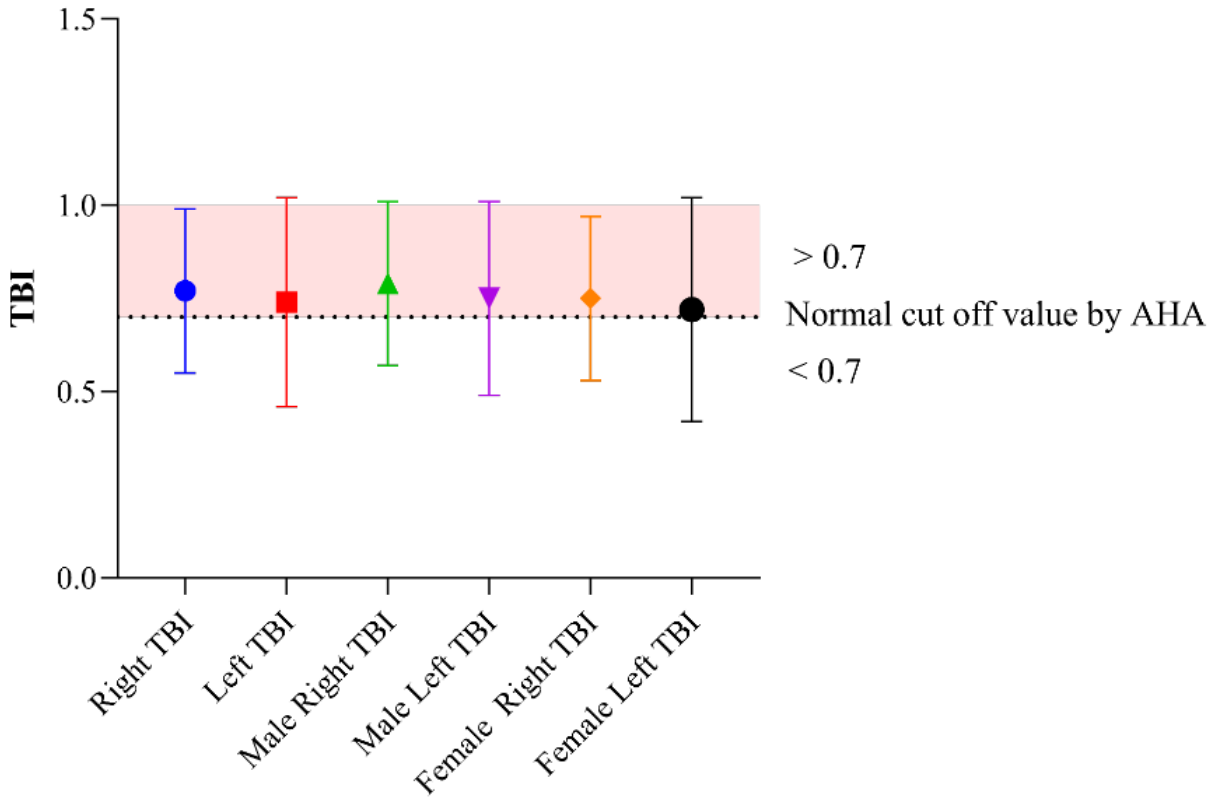
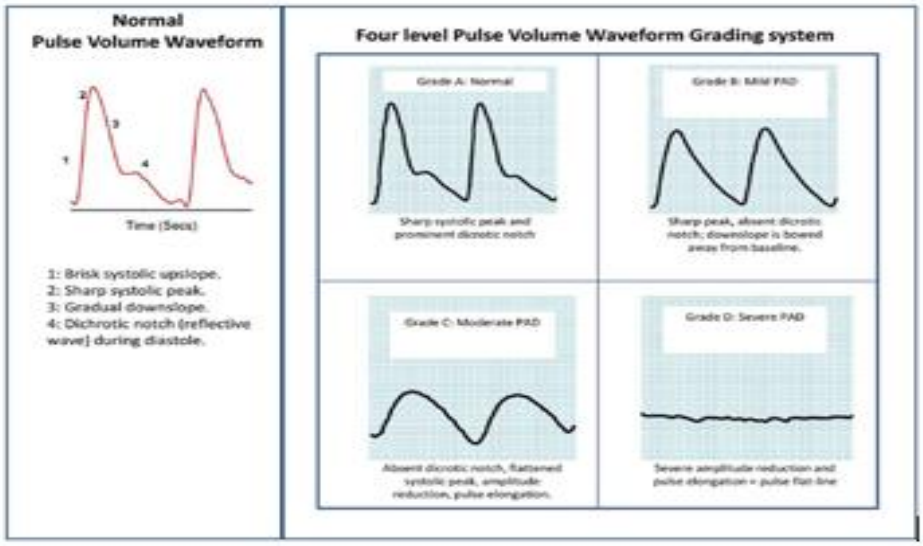


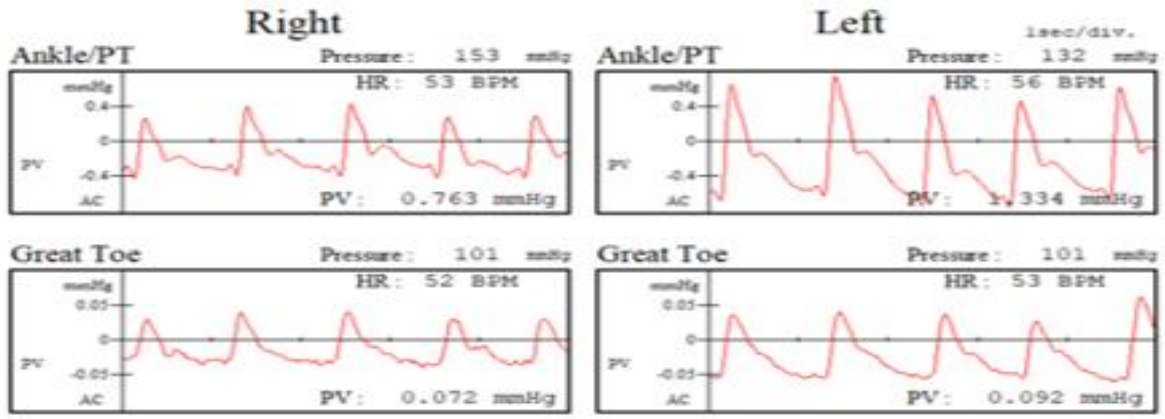
Figure 7: Showing the comparison between observed normal TBI and American Heart Association cut-off.

4.3.3 Comparison of observed Pulse volume waveforms and the reference interpretation

In comparison between the observed PVWs and established reference-based of shape in four graded systems, we found that shapes are similar to the referenced standards PVWs shapes. The formed waveforms had the brisk systolic upstroke, sharp systolic peak, a gradual down, and dicrotic notch as the normal. (Figure 8)



(a)



(b)

Figure 8:(a) Show reference Waveform from and interpretation (b) Waveform from one of the study subjects having similar features as compared to the reference.

4.4 Comparison of ABI, TBI, and PVWs between Young healthy males and females

In comparison between male and female variables of the same side (right for right and left for left). Except for ankle systolic blood pressure, males were found to have significantly higher mean systolic blood pressure than females. The mean ABI was found to be statistically insignificant higher in females (1.01±0.09), (1.07±0.09) than males (0.99±0.08), (1.06±0.07) both left and right respectively. Also participants' legs with ABI < 1.00, 35(54.7%) left was significantly higher in males than females of the left leg 22(38.6%). The mean of right TBI was higher than the left, though was not significant. However TBI < 0.7 male 12(18.8%) right, 18(28.1%) left and female 18(31.6%) right, 23(40.4%) left (table 5 and figure 12)

Table 6:The difference in mean ABI and TBI between male and female

	Male (n =64)		Female (n = 57)		P - value	
Parameter	Right	Left	Right	Left	Right	Left
Brachial Blood Pressure (mmhg)	131±12	129±11	125±10	123±10	0.004 (df=119)	0.007 (df=119)
Resting pulse rate (bpm)	69±11	69±11	76±10	76±10	0.001 (df=118)	0.001 (df=118)
Ankle Blood Pressure(PT)(mmhg)	140±14	131±11	136±10	128±11	0.120 (df=119	0.282 (df=119)
Toe Blood Pressure(mmhg)	105±18	99±18	95±16	92±20	0.003 (df=119)	0.040 (df=119)
ABI	1.06±0.07	0.99±0.08	1.07±0.09	1.01±0.09	0.319 (df=119)	0.084 (df=119)
ABI<1.0	13(20.3)	35(54.7)	10(17.5)	22(38.6)	0.698 (df=1)	0.077 (df=1)
ABI<0.9	1(1.6)	9(14.1)	1(1.8)	6(10.5)	0.934 (df=1)	0.593 (df=1)
TBI	0.79±0.11	0.75±0.13	0.75±0.11	0.72±0.15	0.055 (df=119)	0.249 (df=119)
TBI< 0.7	12 (18.8)	18(28.1)	18(31.6)	23(40.4)	0.140 (df=1)	0.181 (df=1)
TBI< 0.6	3(4.7)	8(12.5)	5 (8.8)	11(19.3)	0.473 (df=1)	0.328 (df=1)

4.5 Factors Affecting ABI and TBI

Multiple linear regression using enter method was used to determine the relationship between ABI and sex, height, BMI and, brachial blood pressure. The dependent variable was ABI, and the determinants (independent) were sex, height, BMI and, Brachial blood pressure. This study found that only the brachial blood pressure is the predictor of the ABI with a negative correlation ($p < 0.001$, $t = -4.026$) right, $p<0.001$, $t=-4.262$) left (table 7)

When multiple linear regression was used to find the relationship between TBI and sex, height, BMI, and brachial blood pressure. The result showed that there is positive correlation between the sex (male) and TBI with the $t=2.682$, $p= 0.008$(right) $t=0.438$, p 0.002(left) negative correlation between height and TBI with $t= -2.090$, $p =0.039$(right) $t=-0.003$, p 0.063(left). (Table 7)

Table 7:Estimated regression coefficients from the multiple linear regression models to predict ABI and TBI

	Unstandardized Coefficients		Standardized		95.0% CI		
Variables	B	Standard error	Coefficient β	t	Lower	Upper	p-value
Left Ankle Brachial Index							
Male	-0.023	0.019	-0.133	-1.181	0.06	0.02	0.240
Height (cm)	0.000	0.001	0.026	0.0256	-0.002	0.002	0.799
BMI (kg/m^2)	-0.004	0.003	-0.128	-1.335	-0.011	0.002	0.184
Right Brachial BP(mmhg)	-0.003	0.001	-0.375	-4.262	-0.004	-0.001	< 0.001
Right Ankle Brachial Index							
Male	0.003	0.019	0.019	0.168	-0.34	0.040	0.867
Height (cm)	-0.001	0.001	-0.057	-0.539	-0.003	0.002	0.591
BMI (kg/m^2)	-0.001	0.003	-0.034	-0.350	-0.007	0.005	0.727
Right Brachial BP(mmhg)	-0.003	0.001	-0.365	-4.026	-0.004	-0.001	< 0.001
Left Toe Brachial Index							
Male	0.063	0.033	0.230	1.878	-0.003	0.129	0.002
Height (cm)	-0.002	0.002	-0.142	-1.277	-0.006	0.001	0.204
BMI (kg/m^2)	0.003	0.006	0.049	0.467	-0.08	0.014	0.641
Right Brachial BP(mmhg)	-0.001	0.001	-0.086	0.0898	-0.003	0.001	0.371
Right Toe Brachial Index							
Male	0.072	0.027	0.322	2.682	0.019	0.126	0.008
Height (cm)	-0.003	0.002	-0.228	-2.090	-0.006	0.00	0.039
BMI (kg/m^2)	0.002	0.005	0.037	0.366	-0.007	0.001	0.715
Right Brachial BP(mmhg)	0.000	0.001	-0.013	-0.141	-0.002	0.002	0.888

CHAPTER FIVE

5.0 DISCUSSIONS

In this study we found right ABI being significantly higher than left, both in general and sex category, likewise for TBI which was insignificant. Comparable results were obtained when ABI, TBI, and PVWs were compared with internationally established reference ranges.

5.1 Ankle Brachial Index and Toe Brachial Index

In this study, we found mean Ankle Brachial Index (ABI) of 1.06 and 1.00 right and left respectively. When right and left were compared statistically, the right mean ABI was significantly higher than left both in combined and sex categorized analysis. Right, left differences in ABI have been previously reported and consistently found to be higher on the right side(56,76). The variability in blood pressure measurements (brachial, ankle) may explain higher ABI on the right side(56).

On comparing the observed ABI ranges with AHA/ACC normal reference range, the upper limit was within the normal range and lower limits fall out of the normal range. In the current study, the lower limit in 95% confidence interval ABI was 0.9 -0.98 and 0.82-0.91 right and left respectively which is described as the borderline. These results are reflected in the AHA scientific statement in the review study, which reported a lower limit of 0.85-0.97(47,77).

These results are likely to be related to young age, as ABI tends to increase with age from childhood who tend to have lower values of ABI (52). The study done by Watanabe et al found mean ABI of 1.06 and 1.05 right and left in young healthy medical students(20). Similarly study done by Neboshi et al in children and adolescent ABI of 1.03 boys and 1.04 girls, with a 0.02 lower compared to 20-29 years (78). This signifies the low normal value of ABI in younger age when compared to values obtained from adults(56,76). However, a significant number of participants' legs 23(19%) right and 57(47%) left with ABI of <1.00 was observed. Similar results were reported by Watanabe Y et al where 18.1% of men and 25.6% of women had ABI <1.00. Therefore this does not always signify vascular disease at this young age (20).

Toe Brachial Index (TBI) is considered sensitive as compared to Ankle Brachial Index (ABI) especially when there is blood vessel calcification but also being heat sensitive. In this study of

young healthy adults, the mean TBI was found to be 0.77 and 0.75 for right and left respectively. Similar results were also reported by a study done by Muro et al and Brooks, the mean TBI was 0.75 and 0.71 respectively reported by Hoyer et al in a literature review study (34). When right and left TBI were compared, right TBI was higher than left with no statistical significance when analyzed in the whole sample and male and female separately. These results match those observed in the study done by Watanabe et al and Quong et al in medical students(20,33)

When the obtained TBI was compared with the AHA reference cut-off, the mean and upper limits of TBI fell within the normal range and the lower limit was out of the lower limits. In this study, we found the 95% confidence interval of TBI was 0.55-0.66 and 0.46-0.6 right and left respectively. These results fall within the normal lower limit of TBI (0.49-0.74) as reported in a study review done by Hoyer et al (34). These lower values are explained by the temperature-sensitive of the toe of which in this study room temperature was maintained at 23^0C-24^0C, no limb preheating method applied. Contrary to this study applying limb preheating, Quong et al in a study that enrolled young medical students reported a higher mean TBI of 0.96 left and 0.95 right (33,34).Besides the presence of lack of global consensus of the cut-off value for TBI (0.6 or 0.7). Participant legs with TBI <0.7 having normal ABI and Pulse Volume Waveforms(PVWs) was observed, a similar finding reported by Watanabe et al(20). This explains the existing controversy of TBI cut-off value of 0.7 to directly confirm the presence of abnormal peripheral arterial status.

5.2 Ankle Brachial Index and Toe Brachial Index between male and female

On sex categorical analysis, the mean ABI for females (1.07 right and 1.01 left) was slightly higher than males (1.06 right and 0.99 left), by 0.01 and 0.02 respectively. Similar results were reported by S.Male et al in the study involving young adults aged 20 to 40 years and the difference was (1.14 female and 1.12 male) 0.02. Though was not statistically significant (51). However several studies reported males to have higher ABI than females a study by Watanabe et al and Neboshi et al males had higher ABI than females (20). ABI < 1 was observed more in males than females which is contrary to the study by Watanabe et al.

The mean Toe Brachial Index(TBI) obtained in the gender category was found to be within the normal limit range but slightly lower when compared to others as reported by Hoyer et al in the study to describe the normal value for TBI(34). The mean TBI was higher in males than females, which the difference was insignificant. The same finding was reported by Quong et al and Watanabe et al in a study involving young medical students(20,33). However TBI of < 0.7 was observed more in females, the comparable result was observed by Watanabe et al which does not exactly signify there is a vascular disease(20).

5.3 Factors Affecting Ankle Brachial Index and Toe Brachial Index

The brachial blood pressure was found to be an independent factor affecting ABI with a significant negative correlation. When brachial blood pressure increase the ABI tends to decrease. The same finding was reported by S.Male et al(51). This poses implication on ABI interpretation which need to be considered in clinical practice in diagnosing peripheral arterial disease. However, height, Body mass index, and sex had no effect. Contrary results were reported in a study by Aboyan et al where he found a correlation between ABI and sex, where being female was associated with lower ABI and taller with high ABI (62).

In running multiple linear regression being male had a positive correlation with TBI which is associated with high TBI, while height had a negative correlation. As the height increase TBI decreases.

5.4 Pulse Volume Waveforms (PVWs)

In this study, the Pulse Volume Waveforms were found to be normal based on the shape description of four grade system. The waveforms had a high dicrotic notch on the down stroke and normal pulse waveform with low amplitude in most of the participants. These findings were also reported by Watanabe Y et al were despite the young adult having ABI <1.0 or 0.9 or TBI <0.7 or 0.6 they had normal pulse waveforms(20).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

The normal range obtained from young healthy black African Tanzanians is ABI (0.9-1.22 right, 0.82-1.18 left) and TBI (0.55-0.99 right, 1.02left) which are slightly lower than the established standards.

Despite comparable values between our population mean ABI and TBI with that of AHA, interpretation of right and left ABI in healthy young black Africans, using established cut-offs should be done with caution. In addition, given the findings of ABI and TBI lower than established standards for normal in apparently healthy young adults lower values for ABI and TBI might not necessarily mean abnormalities in this age group. Further research to clarify these findings and confirm whether the lower limit of normal references in a population of healthy young adults should be lowered, is warranted

6.1 STRENGTH OF THE STUDY

This is the first physiological study was done in young healthy black African in Tanzania to assess the normal peripheral arterial parameter (ABI, TBI, and PVWs) and compare with the international established reference normal values for peripheral arterial status.

6.2 LIMITATION ON THE STUDY

The spectral Doppler (duplex) sonography and contrast angiography was not done to ascertain the enrollment of normal participant.

The study was done among young healthy black African students in the 20s of mainly homogeneous characteristics. Thus more studies are needed for different age groups, study populations, and study areas.

REFERENCES

1. sibley et al. Noninvasive Physiologic Vascular Studies: A Guide to Diagnosing Peripheral Arterial Disease 1. pubmed. 2017;37(1):346–57.

2. London GM, Pannier B. Arterial functions: how to interpret the complex physiology. Nephrol Dial Transplant. 2010 Dec 1;25(12):3815–23.

3. Shabani Varaki E, Gargiulo GD, Penkala S, Breen PP. Peripheral vascular disease assessment in the lower limb: A review of current and emerging non-invasive diagnostic methods. Vol. 17, BioMedical Engineering Online. BioMed Central Ltd.; 2018. p. 1–27.

4. WINSOR T. Influence of arterial disease on the systolic blood pressure gradients of the extremity. Am J Med Sci. 1950;220:117–26.

5. Lewis JEA, Owens DR. The pulse volume recorder as a measure of peripheral vascular status in people with diabetes mellitus. Diabetes Technol Ther. 2010 Jan 1;12(1):75–80.

6. Briefing Note-Tanzania [Internet]. [cited 2021 Mar 6]. Available from: http://blogs.worldbank.org/developmenttalk/youth-bulge-a-demographic-dividend-or-a-

7. Walton S, Dezateux C, Williams J, Wells J. Standard Operating Procedures: Adult Anthropometry EDITORS Acknowledgements. 2013 [cited 2021 Jan 7]; Available from: http://discovery.ucl.ac.uk/1485682/

8. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. J Hypertens. 2018 Oct;36(10):1953–2041.

9. WHO. definition and diagnosis of diabetes mellitus and intermediate hyperglycemia RepoRt of a WHo/IDf ConsultatIon. 2006.

10. Leone A, Landini L, Leone A. What is Tobacco Smoke? Sociocultural Dimensions of

the Association with Cardiovascular Risk. Curr Pharm Des. 2010 Aug 6;16(23):2510–7.

11. Global Physical Activity Questionnaire Analysis Guide GPAQ Analysis Guide Global Physical Activity Questionnaire (GPAQ) Analysis Guide [Internet]. Available from: http://www.who.int/chp/steps/GPAQ/en/index.html

12. Libretti S, Puckett Y. Physiology, Homeostasis. StatPearls [Internet]. 2021 May 9 [cited 2021 Oct 23]; Available from: https://www.ncbi.nlm.nih.gov/books/NBK559138/

13. Bohr AH, Fuhlbrigge RC, Pedersen FK, de Ferranti SD, Müller K. Premature subclinical atherosclerosis in children and young adults with juvenile idiopathic arthritis. A review considering preventive measures. Vol. 14, Pediatric Rheumatology. BioMed Central Ltd.; 2016. p. 3.

14. Roman WP, Martin HD, Sauli E. Cardiovascular diseases in Tanzania: The burden of modifiable and intermediate risk factors. J Xiangya Med. 2019;4:33–33.

15. Mcnamara JJ, Molot MA, Stremple JF, Cutting RT. Coronary Artery Disease in Combat Casualties in Vietnam. JAMA J Am Med Assoc. 1971;216(7):1185–7.

16. Ma J, Liu M, Chen D, Wang C, Liu G, Ran X. The Validity and Reliability between Automated Oscillometric Measurement of Ankle-Brachial Index and Standard Measurement by Eco-Doppler in Diabetic Patients with or without Diabetic Foot. Int J Endocrinol. 2017;2017.

17. Yokoi Y. Basics of Angiography for Peripheral Artery Disease. In: Angiography and Endovascular Therapy for Peripheral Artery Disease. InTech; 2017. p. 870–7.

18. Olin JW, Sealove BA. Peripheral artery disease: Current insight into the disease and its diagnosis and management. Mayo Clin Proc. 2010;85(7):678–92.

19. Bérard AM, Bedel A, Le Trequesser R, Freyburger G, Nurden A, Colomer S, et al. Novel Risk Factors for Premature Peripheral Arterial Occlusive Disease in Non-Diabetic Patients: A Case-Control Study. PLoS One. 2013;8(3):e37882.

20. Watanabe Y, Masaki H, Yunoki Y, Tabuchi A, Morita I, Mohri S, et al. Ankle-Brachial Index, Toe-Brachial Index, and Pulse Volume Recording in Healthy Young Adults. Ann Vasc Dis. 2015;8(3):227–35.

21. Špan M, Geršak G, Millasseau SC, Meža M, Košir A. Detection of peripheral arterial disease with an improved automated device: Comparison of a new oscillometric device and the standard Doppler method. Vasc Health Risk Manag. 2016;29(12):305–11.

22. Gerry Fowkes FR, Aboyans V, I Fowkes FJ, McDermott MM, A Sampson UK, Criqui MH. Peripheral artery disease: epidemiology and global perspectives. Nat Publ Gr. 2016;14(3):156–70.

23. Song P, Rudan D, Zhu Y, Fowkes FJI, Rahimi K, Fowkes FGR, et al. Global, regional, and national prevalence and risk factors for peripheral artery disease in 2015: an updated systematic review and analysis. Lancet Glob Heal. 2019;7(8):e1020–30.

24. Diehm C, Allenberg JR, Pittrow D, Mahn M, Tepohl G, Haberl RL, et al. Mortality and vascular morbidity in older adults with asymptomatic versus symptomatic peripheral artery disease. Circulation. 2009;120(21):2053–61.

25. Hennion DR, Siano KA. Diagnosis and treatment of peripheral arterial disease. Am Fam Physician. 2013;88(5):306–10.

26. Hirsch AT, Criqui MH, Treat-Jacobson D, Regensteiner JG, Creager MA, Olin JW, et al. Peripheral arterial disease detection, awareness, and treatment in primary care. J Am Med Assoc. 2001;286(11):1317–24.

27. Olin JW, Allie DE, Belkin M, Bonow RO, Casey DE, Creager MA, et al. ACCF/AHA/ACR/SCAI/SIR/SVM/SVN/SVS 2010 performance measures for adults with peripheral artery disease: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Performance Measures, the American College of Radiolo. Circulation. 2010 Dec 14;122(24):2583–618.

28. Crawford F, Welch K, Andras A, Chappell FM. Ankle brachial index for the diagnosis of lower limb peripheral arterial disease. Cochrane Database of Systematic Reviews. 2016.

29. Rac-Albu M, Iliuta L, Guberna SM, Sinescu C. The role of ankle-brachial index for predicting peripheral arterial disease. Maedica (Buchar). 2014 Sep;9(3):295–302.

30. Norman PE, Eikelboom JW, Hankey GJ. Peripheral arterial disease: Prognostic significance and prevention of atherothrombotic complications. Med J Aust. 2004;181(3):150–4.

31. Mohler ER, Treat-Jacobson D, Reilly MP, Cunningham KE, Miani M, Criqui MH, et al. Utility and barriers to performance of the ankle-brachial index in primary care practice. Vasc Med. 2004;9(4):253–60.

32. Zobel EH, von Scholten BJ, Reinhard H, Persson F, Hansen TW, Parving HH, et al. Toe–brachial index as a predictor of cardiovascular disease and all-cause mortality in people with type 2 diabetes and microalbuminuria. Diabetologia. 2017;60(10):1883–91.

33. Quong WL, Fung ATH, Yu RY, Hsiang YNH. Reassessing the normal toe-brachial index in young healthy adults. In: Journal of Vascular Surgery. 2016. p. 652–6.

34. Høyer C, Sandermann J, Petersen LJ. The toe-brachial index in the diagnosis of peripheral arterial disease. J Vasc Surg. 2013;58(1):231–8.

35. Halperin JL. Evaluation of patients with peripheral vascular disease. Thromb Res. 2002;106(6):v303-11.

36. Sumpio BE, Benitez E. Pulse volume recording for peripheral vascular disease diagnosis in diabetes patients. J Vasc Diagnostics. 2015;2015(3):33–9.

37. Gichu M, Asiki G, Juma P, Kibachio J, Kyobutungi C, Ogola E. Prevalence and predictors of physical inactivity levels among Kenyan adults (18-69 years): An analysis of STEPS survey 2015. BMC Public Health. 2018;18(3):1–7.

38. Criqui MH, Langer RD, Fronek A, Feigelson HS, Klauber MR, McCann TJ, et al. Mortality over a Period of 10 Years in Patients with Peripheral Arterial Disease. N Engl J Med. 1992;326(6):381–6.

39. Sarah Shali Matuja, Patricia Munseri KK. The burden and outcome of stroke in young adults in a Tanzanian Tertiary Hospital: A Comparison with older Adults. 2020.

40. Hunter DJ. Gene-environment interactions in human diseases. Nature Reviews Genetics. 2005. p. 287–98.

41. Boehme AK, Esenwa C, Elkind MSV. Stroke Risk Factors, Genetics, and Prevention. Circulation Research. 2017. p. 472–95.

42. Tripathy K, Nanda T. The Influence of Environmental and Genetic Factors on Various Disorders and Diseases. J Genet Syndr Gene Ther. 2011;

43. Katayev A, Balciza C, Seccombe DW. Establishing reference intervals for clinical laboratory test results: Is there a better way? Am J Clin Pathol. 2010;133(2):180–6.

44. Adeli K. Clinical laboratory reference intervals in pediatrics: Current gaps and recent advance. Clin Biochem. 2011;

45. Carter SA. Indirect systolic pressures and pulse waves in arterial occlusive diseases of the lower extremities. Circulation. 1968;37(4):624–37.

46. Yao ST, Hobbs JT, Irivne WT. Ankle systolic pressure measurements in arterial disease affecting the lower extremities. Br J Surg. 1969;56(9):676–9.

47. McDermott MM, Guralnik JM, Tian L, Liu K, Ferrucci L, Liao Y, et al. Associations of Borderline and Low Normal Ankle-Brachial Index Values With Functional Decline at 5-Year Follow-Up. The WALCS (Walking and Leg Circulation Study). J Am Coll Cardiol. 2009;53(12):1056–62.

48. Fowkes G, Fowkes FGR, Murray GD, Butcher I, Heald CL, Lee RJ, et al. Ankle

brachial index combined with Framingham risk score to predict cardiovascular events and mortality: A meta-analysis. JAMA - J Am Med Assoc. 2008;300(2):197–208.

49. Tummala S, Scherbel D. Clinical Assessment of Peripheral Arterial Disease in the Office: What Do the Guidelines Say? Semin Interv Radiol. 2018;35:365–77.

50. Doraiswamy VA, Giri J, Iii EM, Doraiswamy V. Premature peripheral arterial disease-difficult diagnosis in very early presentation. Vol. 18, Int J Angiol. 2009.

51. Male S, Coull A, Murphy-Black T. Preliminary study to investigate the normal range of Ankle Brachial Pressure Index in young adults. J Clin Nurs. 2007 Oct;16(10):1878–85.

52. Ishida A, Miyagi M, Kinjo K, Ohya Y. Age- and sex-related effects on ankle-brachial index in a screened cohort of Japanese: The Okinawa Peripheral Arterial Disease Study (OPADS). Eur J Prev Cardiol. 2014;21(6):712–8.

53. Gerhard-Herman MD, Gornik HL, Barrett C, Barshes NR, Corriere MA, Drachman DE, et al. 2016 AHA/ACC Guideline on the Management of Patients with Lower Extremity Peripheral Artery Disease: Executive Summary. Vol. 22, Vascular Medicine (United Kingdom). SAGE Publications Ltd; 2017. p. NP1–43.

54. Aboyans V, Ricco JB, Bartelink MLEL, Björck M, Brodmann M, Cohnert T, et al. 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS). European Heart Journal. 2018. p. 763–816.

55. Mashili F, Joachim A, Aboud S, McHembe M, Chiwanga F, Addo J, et al. Prospective exploration of the effect of adiposity and associated microbial factors on healing and progression of diabetic foot ulcers in Tanzania: Study protocol of a longitudinal cohort study. BMJ Open. 2019 Dec 16;9(12):e031896.

56. Smith FB, Lee AJ, Price JF, Van Wijk MCW, Fowkes FGR. Changes in ankle brachial index in symptomatic and asymptomatic subjects in the general population. J Vasc

Surg. 2003;22(4):1032–41.

57. Aboyans V, Criqui MH, Abraham P, Allison MA, Creager MA, Diehm C, et al. Measurement and interpretation of the Ankle-Brachial Index: A scientific statement from the American Heart Association. Circulation. 2012 Dec 11;126(24):2890–909.

58. Fowkes FGR, Housley E, Cawood EHH, Macintyre CCA, Ruckley C V., Prescott RJ. Edinburgh artery study: Prevalence of asymptomatic and symptomatic peripheral arterial disease in the general population. Int J Epidemiol. 1991;20(2):384–92.

59. Hiatt WR, Hoag S, Hamman RF. Effect of diagnostic criteria on the prevalence of peripheral arterial disease: The San Luis Valley Diabetes Study. Circulation. 1995;91(5):1472–9.

60. Bird CE, Criqui MH, Fronek A, Denenberg JO, Klauber MR, Langer RD. Quantitative and qualitative progression of peripheral arterial disease by non-invasive testing. Vasc Med. 1999;4(1):15–21.

61. London GM, Guerin AP, Pannier B, Marchais SJ, Stimpel M. Influence of sex on arterial hemodynamics and blood pressure: Role of body height. In: Hypertension. 1995. p. 514–9.

62. Aboyans V, Criqui MH, McClelland RL, Allison MA, McDermott MMG, Goff DC, et al. Intrinsic contribution of gender and ethnicity to normal ankle-brachial index values: The Multi-Ethnic Study of Atherosclerosis (MESA). J Vasc Surg. 2007;45(2):319–27.

63. Stoffers HEJH, Kester ADM, Kaiser V, Rinkens PELM, Kitslaar PJEHM, Knottnerus JA. The diagnostic value of the measurement of the ankle-brachial systolic pressure index in primary health care. J Clin Epidemiol. 1996;49(12):1401–5.

64. Zheng ZJ, Sharrett AR, Chambless LE, Rosamond WD, Nieto FJ, Sheps DS, et al. Associations of ankle-brachial index with clinical coronary heart disease, stroke and preclinical carotid and popliteal atherosclerosis: The Atherosclerosis Risk in

Communities (ARIC) study. Atherosclerosis. 1997;131(1):115–25.

65. Zheng ZJ, Rosamond WD, Chambless LE, Nieto FJ, Barnes RW, Hutchinson RG, et al. Lower extremity arterial disease assessed by ankle-brachial index in a middle-aged population of African Americans and whites: The Atherosclerosis Risk in Communities (ARIC) Study. American Journal of Preventive Medicine. 2005. p. 42–9.

66. Carmelli D, Fabsitz RR, Swan GE, Reed T, Miller B, Wolf PA. Contribution of genetic and environmental influences to Ankle-Brachial blood pressure index in the NHLBI twin study. Am J Epidemiol. 2000;151(5):452–8.

67. Allison MA, Peralta CA, Wassel CL, Aboyans V, Arnett DK, Cushman M, et al. Genetic ancestry and lower extremity peripheral artery disease in the Multi-Ethnic Study of Atherosclerosis. Vasc Med. 2010;15(5):351–9.

68. Phillips SA, Mahmoud AM, Brown MD, Haus JM. Exercise interventions and peripheral arterial function: Implications for cardio-metabolic disease. Prog Cardiovasc Dis. 2015 Mar 1;57(5):521–34.

69. Al-qaisi M, Nott DM, King DH, Kaddoura S. Ankle Brachial Pressure Index (ABPI): An update for practitioners. 2009;5:833–41.

70. Vowden K, Specialist N, Infirmary BR, Vowden P, Surgeon CV. Doppler and the ABPI : how good is our understanding ? 2001;10(6).

71. Sullivan GM, Feinn R. Using Effect Size—or Why the P Value Is Not Enough. J Grad Med Educ. 2012;

72. Solla F, Tran A, Bertoncelli D, Musoff C, Bertoncelli CM. Why a P -Value is Not Enough. Clin Spine Surg. 2018;31:385–8.

73. Samargandi OA, Al-Taha M, Moran K, Al Youha S, Bezuhly M. Why the p Value Alone Is Not Enough: The Need for Confidence Intervals in Plastic Surgery Research. In: Plastic and Reconstructive Surgery. 2018. p. 152e-62e.

74. Agu CE, Uchendu IK, Nsonwu AC, Okwuosa CN, Achukwu PU. Prevalence and associated risk factors of peripheral artery disease in virologically suppressed HIV-infected individuals on antiretroviral therapy in Kwara state, Nigeria: A cross sectional study. BMC Public Health. 2019 Aug 20;19(1):1–2.

75. Krishnan MN, Geevar Z, Mohanan PP, Venugopal K, Devika S. Prevalence of peripheral artery disease and risk factors in the elderly: A community based cross-sectional study from northern Kerala, India. Indian Heart J. 2018 Nov 1;70(6):808–15.

76. Hiatt WR, Marshall JA, Baxter J, Sandoval R, Hildebrandt W, Kahn LR, et al. Diagnostic methods for peripheral arterial disease in the san luis valley diabetes study. J Clin Epidemiol. 1990;43(6):597–606.

77. Aboyans V, Criqui MH, Abraham P, Allison MA, Creager MA, Diehm C, et al. Measurement and interpretation of the Ankle-Brachial Index: A scientific statement from the American Heart Association. Circulation. 2012 Dec 11;126(24):2890–909.

78. Niboshi A, Hamaoka K, Sakata K, Inoue F. Characteristics of brachial-ankle pulse wave velocity in Japanese children. Eur J Pediatr. 2006 Sep;165(9):625–9.

79. Chanana Paquissi F, Bimbi Paquissi Cuvinje A, Bailundo Cuvinje A. Prevalence of Peripheral Arterial Disease among Adult Patients Attending Outpatient Clinic at a General Hospital in South Angola. 2016;

80. Makowsky M, McMurtry MS, Elton T, Rosenthal M, Gunther M, Percy M, et al. Prevalence and Treatment patterns of lower extremity peripheral arterial disease among patients at risk in ambulatory health settings. Can J Cardiol. 2011 May;27(3):38-.e11.

APPENDICES:

APPENDIX 1: INFORMED CONSENT FORM-ENGLISH VERSION

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

SCHOOL OF MEDICINE

DEPARTMENT OF PHYSIOLOGY

Consent to participate in the study to determine the normal Peripheral Arterial parameters in young healthy black African in Tanzania at Muhimbili University of Healthy and Allied Sciences (MUHAS).

NAME …….

REG.No ……..

AGE…….

My name is Dr. Tuntufyege Mwasanjobe a postgraduate student in the Department of Physiology at Muhimbili University of Healthy (MUHAS). I am conducting a research study on the determination of normal peripheral Arterial parameters in young healthy black African in Tanzania**.** I hereby request for participation

Purpose of the study

To determine normal peripheral arterial parameters (ABI, TBI, and PVWs) and compare with internationally established references in young healthy black African in Tanzania at MUHAS.

How to participate

Participants, who will be willing to participate, will sign the consent form. Then will be interviewed for social demographic data and risk factors and physical measurements will be taken.

Confidentiality

Information that will be gathered will be confidential and held with a high level of confidentiality. The information will be to determine normal peripheral arterial parameters (ABI, TBI, and PVWs) and compare them with internationally established references that are unknown in our setting.

Cost

There will be no cost/any payment for participation in this study

Voluntary participation and right to withdraw from the study

Participation in this study is voluntary and you have the right to withdraw from the study at any time. Any decision you make will not affect anything.

Risk

There will be no risk because; no invasive procedure is being employed only physical measurement after 5 minutes of rest.

Benefits

Your participation will enable you to know the status of peripheral arteries. The results will provide the information if the normal peripheral arterial parameters in young healthy black African reflect the internationally established references ranges. Also will establish a base for follow-up studies in our setting.

I will be thankful if you agree to participate in this study.

Investigator's statement

I the investigator have educated the research participant on the purpose and applications of this study

Signed…….date……..

If have any question during the study, contact me through

Dr Tuntufyege Mwasanjobe

Principal Investigator

Muhimbili University of Health and Allied Sciences (MUHAS)

Department of Physiology

P.O.BOX 65001 Dar es Salaam, Mobile phone: 0752 900777

Email: tuntufye07@yahoo.com

In case of any information about your rights as a participant in this study please contact;

The Chairperson of the Research and Publication Committee

Muhimbili University of Health and Allied Sciences (MUHAS)

P.O.BOX 65001 Dar es salaam Tel. 022-2152489

Participant's Statement

I am willing to participate in the study to determine normal peripheral Arterial parameters in young healthy black African in Tanzania at MUHAS. I do this with a full understanding of the purpose of the study and procedure involved which include filling out the questionnaire and having physical measurements, all of which have been explained to me by Dr. Tuntufyege Mwasanjobe

Signature of participant…… Date ……

KIAMBATISHO II. FOMU YA OMBI LA RIDHAA -KISWAHILI
CHUO KIKUU CHA SAYANSI YA AFYA NA USHIRIKA MUHIMBILI

SHULE YA MEDICINE

KITENGO CHA FIZIOLOGIA

Idhini ya kushiriki katika utafiti wa tathmini ya vigezo vya kawaida vya mishipa ya ateri ya pembeni kwa vijana weusi wa kiafrika wenye Afya Tanzania katika Chuo kikuu cha sayansi ya afya na ushirika Muhimbili

Jina……..……..

Namba ya Usajili……..

Tarehe ya tafiti…….……

Kusudi la Tafiti

Kutathimini vigezo vya kawaida vya mishipa ya ateri ya pembeni (ABI,TBI and PVWs) kulingana na marejeo yaliowekwa kimataifa kwa vijana weusi wa kiafrica wenye afya Tanzania katika Chuo kikuu cha sayansi ya afya na ushirika Muhimbili

Jinsi ya kushiriki katika utafiti huu

Mshiriki atakaye kuwa tayari kushiriki, atasaini fomu ya idhini . kisha ataulizwa maswali mafupi ya taarifa za kiutambulisho na sababu hatarishi na vipimo vya uchunguzi wa mwili kuchukuliwa.

Utunzaji wa siri

Taarifa ambayo itakusanywa katika utafiti huu itakua ni siri,na zitatunzwa kwa usiri. Taarifa itakuwa kutathimini vigezo vya kawaida vya mishipa ya ateri ya pembeni(ABI,TBI and PVWs) kulingana na marejeo yaliowekwa kimataifa ambayo hayajulikani katika mazingira yetu.

Gharama za Ushiriki

Hakutakuwa na gharama wala malipo yoyote kushiriki katika utafiti huu

Hiyari ya kushiriki na kujitoa katika utafiti huu

Ushiriki katika utafiti huu ni wa hiyari na pia una haki ya kujitoa wakati wowote unapohisi kufanya hivyo.Maamuzi yoyote utakayo fanya hayata kuwa na madhara yeyote.

Madhara ya kushiriki

Hakutakuwa na madhara yeyote yatakayo mpata mshiriki katika utafiti huu, na itahusisha uchunguzi wa mwili wa nje.

Manufaa ya kushiriki katika utafiti huu

Ushiriki wako utakuwezesha kujua hali yako ya mishipa ya ateri ya pembeni. Pia matokeo yatatoa taarifa ikiwa vigezo vya kawaida vya mishipa ya ateri ya pembeni kwa vijana wa kiafrika wenye afya inalingana na vigezo vya kimataifa vilivyo wekwa. Pia itaweka msingi wa ufuatiliaji wa mabadiliko.

Nitashukuru ikiwa utakubali kushiriki katika utafiti huu.

Kauli ya Mtafiti

Mimi mtafiti nimemuelewesha mshiriki katika utafiti huu kuhusu huu utafiti.

Sahihi…….. tarehe ……

Mawasiliano Kwa wahusika

Kwa maswali au maoni kuhususiana na utafiti huu tafadhali wasiliana na wafuatao:

Dr Tuntufyege Mwasanjobe

Mtafiti mkuu

Chuo Kikuu cha Afya na Tiba Shirikishi Muhimbili

Idara ya Physiology

S.L.P. 65001,

Dar es Salaam

Nambari ya simu : 0752 900777 Barua pepe: tuntufye07@yahoo.com

Kwa mawasiliano zaidi kuhusiana na haki zako kwenye utafiti huu kama mshiriki, tafadhali wasiliana na:

Mwenyekiti a tume ya tafiti na uchapishaji wa tafiti

Chuo Kikuu cha afya na tiba shirikishi Muhimbili

S.L.P. 65001 , Dar es salaam ,Nambari ya simu: 022-2152489

Kauli ya Mshiriki

Mimi niko tayari kushiriki katika utafiti wa tathmini vigezo vya kawaida vya mishipa ya ateri ya pembeni kwa vijana weusi wa kiafrika wenye Afya Tanzania katika Chuo kikuu cha sayansi ya afya na ushirika Muhimbili. Nafanya hivi kwa kuelewa kamili madhumuni ya utafiti na utaratibu unaohusika ambao ni pamoja na kujaza dodoso na kufanyiwa vipimo vya mwili. Ambayo yote nimefafanuliwa na Dr. Tuntufyege Mwasanjobe.

Sahihi ya mshiriki…… Tarehe……

APPENDIX III: QUESTIONNAIRE ENGLISH VERSION

MUHIMBILI UNIVERSITY OF
HEALTH AND ALLIED SCIENCES

SCHOOL OF MEDICINE

DEPARTMENT OF PHYSIOLOGY

The normal Peripheral Arterial parameters in young healthy black African in Tanzania at Muhimbili University of Healthy and Allied Sciences (MUHAS).

Study number……..

REG. No:……..

Study Date…….....

Mobile phone No……...

Part 1: Social Demographic Data

1. Age……
2. Sex a) Male b)Female
3. Marital status
   a) Single
   b) Married or co habiting
   c) Separated
   d) Divorced
   e) Widow
4. Residence of origin (where you come from) a) Rural b) Urban

Part 2: Medical and Social history

5. Do you have first degree relative with following?

Hypertension	Yes	No
Diabetes mellitus	Yes	No
Cardiovascular disease	Yes	No

Life style: cigarette and alcohol intake

6. History of Cigarette smoking within the past 10 years
    a. Yes
    b. No (Skip to 09)
7. Are you currently smoking?
    a. Yes
    b. No
8. If not when did you quit?
    a. Less than a year ago
    b. One year ago
    c. Two years ago
    d. Five years ago
9. Do you drink alcohol?
    a. Yes (Skip to 12)
    b. No
10. Do you have any history of taking alcohol?
    a. Yes
    b. No
11. If yes, when did you quit?
    a. Less than one year
    b. One year ago
    c. Two years ago
    d. Five years ago
12. How often do you drink alcohol?
    a. Regular (5 or more times a week)
    b. Often (between 3 to 5 times a week)
    c. Occasional (Less than 3 times in a week)
    d. I rarely drink (none or few times in a month)
13. What type of alcoholic drink do you take often?
    a. Beer
    b. Red dry wine
    c. Red sweet wine
    d. White dry wine
    e. White sweet wine
    f. Hard liquor (whisky, ram, etc.)
    g. Usually, I mix (mention)
14. On average, how many units of alcohol (bottles, glasses, shots,etc.) do you take when you drink?
    a. More than 2 large bottles of beer
    b. More than 2 small bottles of beer
    c. More than 2 glasses of wine
    d. More than 2 tots/shots of hard liquor
    e. Two large bottles of beer
    f. One to 2 small bottles of beer

g. One to 2 glasses of wine
h. One to 2 tots/shots of hard liquor

Diet: Fruits and Vegetable

15. Do you eat fruits and vegetables?
    a) Yes
    b) No

	Every day	Sometimes	Not
Fruits			
vegetable			

16. How often do you usually eat fruits and vegetables in a week?

Put **v** if **yes** and **x** if **No** in the box

17. On a typical day, how many portions of fruits do you eat?
    a. More than 5 portions
    b. Three to five portions per day
    c. Less than three portions per day
    d. Less than one portion per day
    e. I rarely eat fruits
18. On a typical day, how many portions of vegetables do you eat?
    a. More than 5 portions
    b. Three to five portions per day
    c. Less than three portions per day
    d. Less than one portion per day
    e. I rarely eat vegetables

Physical activity questionnaire

Next, I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself as being a physically active person.

Think first about the time you spend doing work. Think of work as the thing that you have to do such as paid or unpaid work, studying /training, household chores harvesting food/crops, fishing or hunting for food, seeking employment. In answering the following questions 'vigorous physical activity are activities that require hard physical effort and cause a larger increase in breathing or heart rate, 'moderate-intensity activity' are the activity that requires moderate physical effort and causes a small increase in breathing and heart rate.

1. Does your work involve a vigorous-intensity activity that causes a larger increase in breathing and heart rate for at least 10 minutes continuously? E.g. digging, lifting, or carrying heavy loads.
   a) Yes
   b) No **(go to question 4)**
2. In a typical week on how many days do you do vigorous-intensity activity as part of your work?
   The Number of days……
3. How much time do you send doing a vigorous-intensity activity at work on a typical day?
   Hours…… Minutes……
4. Does your work involve moderate-intensity physical activity, that causes a small increase in breathing and heart rate such as brick working for at least 10 minutes continuously
   a) Yes
   b) No **(go to question 7)**
5. In a typical week, on how many days do you do moderate physical activities as part of your work? the Number of days……..
6. How much time do you do spend doing moderate-intensity activity at work spend in a typical day?
   Hours …… Minutes……..

The next questions exclude physical activity at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, shopping to market, to a place of worship

7. Do you walk or use a bicycle (pedal cycle) for at least 10 minutes to get to and from places?
   a) Yes
   b) No **(go to question 10)**

8. In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places? The Number of days……..

9. How much time do you spend walking or bicycling for travel on a typical week?
   Hours…….Minutes……

The Next questions exclude the working and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities

10. Do you do any vigorous-intensity sports fitness or recreational (leisure) activities that cause larger increases in breathing and heart rate for at least 10 minutes continuously? E.g. running or football
    a) Yes
    b) No **(go to question 13)**
11. In a typical week, on how many days do you do vigorous-intensity sports, fitness, or recreational (leisure) activities?
    The Number of days……
12. How much time do you spend doing sports, fitness, and recreational activities on a typical day?
    Hours …… Minutes ……
13. Do you do any moderate-intensity sports, fitness, and recreational (leisure) activities that cause a small increase in breathing or heart rate for at least 10minutes continuously? E.g. cycling, swimming, or volleyball.
    a) Yes

b) No **(go to question 16)**

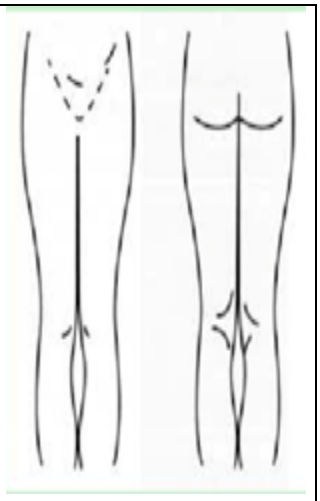
14. In a typical week, how many days do you do moderate-intensity sports, fitness, or recreational (leisure) activities? The Number of days……
15. How much time do you spend doing moderate-intensity sports, fitness, or recreational (leisure) activities? Hours …… Minutes ……

Question about sitting and reclining at work at home, getting to and from places or with friends including time spent sitting on a desk, sitting with friends, traveling in a car, train, reading, playing card or watching television but do not include time spent sleeping

16. How much time do you usually spend sitting or reclining on a typical day? Hour…… minutes ……...

The Edinburgh Claudication Questionnaire (CAD/PVD)

A positive questionnaire diagnosis of claudication is made only if the correct answer is given to all questions

S/n	Questions	Correct answer	
1.	Do you get pain or discomfort in your leg(s) when you walk? unable to walk If you answered yes to question 1, please answer the following questions	Yes ( ) No ( )	
2	Does the pain ever begin when you are standing or sitting still?	Yes ( ) No ( )	
3	Do you get when you walk uphill or in a hurry?	Yes ( ) No ( )	
4	Do you get when you walk at an ordinary pace on the level?	Yes ( ) No ( )	
5	What happens when you stand still? • Usually continue for more than 10 minutes? • Usually disappears in 10 or less minutes?	 ( ) ( )	
6	Where do you get this pain or discomfort? • Mark the place with an X on the diagram		

Positive claudication requirements: 'Yes' to (1), 'No' to (2), 'Yes' to (3), 'usually disappear in 10 minutes or less' to (5): grade 1= 'No' to (4), grade 2 = 'Yes' to (4). Meeting these criteria plus the mark

Definite claudication: mark on the calf, **atypical claudication:** mark on thigh or buttock

No claudication: no calf pain and if a mark on hamstring muscles, feet, shins, joints radiating.

Part 4: measurements

Body Mass Index (BMI)

Weight (Kg) ……	BMI= $\frac{\textbf{Weight(Kg)}}{\textbf{Height(m2)}}$ = ……..=…….
Height (cm) …… m……	

Waist to Hip Ratio (WHR)

Waist Circumference (cm) ……	WHR= $\frac{\textbf{Waist Circumference(cm)}}{\textbf{Hip Circumference (cm)}}$ =……=….....
Hip Circumference (cm) …….	

Pulse Palpation

Site of Palpation	Right leg	Left leg
Posterior Tibia Artery	Yes ( ) No ( )	Yes ( ) No ( )
Dorsalis Pedis Artery	Yes ( ) No ( )	Yes ( ) No ( )
Resting heart rate	Right wrist……	Left wrist ……...

Blood Pressure

Right Arm	Left Arm
Systolic BP ……..	Systolic BP ……..
Diastolic BP ……..	Diastolic BP ……..

Ankle Brachial Index (ABI)

Brachial BP(mmhg)	Ankle BP(mmhg)	ABI
Right Arm……	Right Ankle: DPA ……. PTA ……..…..	ABI=$\frac{\textbf{Higher Ankle BP}}{\textbf{Higher brachial BP}}$= …… ABI ……..
Left Arm ……	Left Ankle: DPA ……. PTA …….	ABI=$\frac{\textbf{Higher Ankle BP}}{\textbf{Higher brachial BP}}$= …… ABI ……..

Toe Brachial Index (TBI)

Brachial SBP	Tibia SBP	TBI
Right Arm……..	Right toe…….	TBI=$\frac{\textbf{\textit{Hight Toe SBP}}}{\textbf{\textit{Hight brachial SBP}}}$=…….. TBI=…….
Left Arm ……...	Left toe……..	TBI=$\frac{\textbf{\textit{Hight Toe SBP}}}{\textbf{\textit{Hight brachial SBP}}}$=…….. TBI=…….

Pulse Volume Waveforms

Grade	Right			Left		
	Monophasic	Biphasic	Triphasic	Monophasic	Biphasic	Triphasic
Grade A						
Grade B						
Grade C						
Grade D						

KIAMBATISHO IV: DODOSO

CHUO KIKUU CHA SAYANSI YA AFYA NA USHIRIKA MUHIMBILI

SHULE YA MEDICINE

KITENGO CHA FIZIOLOGIA

Tathimini ya vigezo vya kawaida vya mishipa ya ateri ya pembeni kwa vijana weusi wa kiafrika wenye afya Tanzania-MUHAS

Namba ya dodoso……

Namba ya usajili……..

Tarehe ya tafiti…….

Sehemu ya kwanza: taarifa/takwimu za jamii

1. Umri……
2. Jinsi
   a) Male
   b) Female
3. Marital status
   a) Hajaoa/hajaolewa
   b) Ameoa /ameolewa
   c) Wanaishi pamoja
   d) Wametengana
   e) Wametalikiana
   f) Mjane/mgane
4. Mahali unakotoka
   a) Mjini b) Kijijini

Sehemu ya 2: family social history

5. Je, una jamaa wa daraja la kwanza mwenye magonjwa yafuatayo?

Magonjwa	Ndio	Hapana
Shinikizo la damu		
kisukari		
Magonjwa ya moyo		

Mtindo wa maisha/Uvutaji wa sigara na unyaji wa pombe.

6. **Historia ya uvutaji wa sigara ndani ya miaka 10**
   a) Ndio
   b) Hapana (luka nenda namba 9)
7. **Je. Unavuta sigara kwa sasa?**

a) **Ndio**
b) **Hapana**

8. **Ikiwa ni hapana, je uliacha lini?**
   a) **Chini ya mwaka mmoja uliopita**
   b) **Mwaka mmoja uliopita**
   c) **Miaka miwili iliyopita**
   d) **Miaka mitano iliyopita**
9. **Unakunywa pombe?**
   a) **Ndio (luka nenda namba 12)**
   b) **Hapana**
10. **Je unahistoria yeyote ya kunywa pombe?**
    a) **Ndio**
    b) **Hapana**
11. **Ikiwa ndio, uliacha lini?**
    a) **Chini ya mwaka mmoja uliopita**
    b) **Mwaka uliopita**
    c) **Miaka miwili iliyopita**
    d) **Miaka mitano iliyopita**
12. **Unakunywa pombe mara ngapi?**
    a) **Kawaida(mara tano au zaidi kwa wiki?**
    b) **Mara nyingi(kati ya mara 3 hadi 5 kwa wiki)?**
    c) **Mara chache (chini ya mara 3 kwa wiki)**
    d) **Mara chache sana(hakuna au mara chache kwa mwezi)**
13. **Ni aina gani ya kileo unachotumia mara kwa mara?**
    a) **Bia**
    b) **Divai nyekundu kavu**
    c) **Divai tamu nyekundu**
    d) **Divai nyeupe kavu**
    e) **Divai tamu nyeupe**
    f) **Pombe kali(whisky,ram)**
    g) **Kawaida huwa nachanganya(taja)**
14. **Kwa kawaida huwa unatumia kiasi gani (chupa,glasi, 'shot') unapokunywa?**
    a) **Zaidi ya chupa 2 kubwa za bia**
    b) **Zaidi ya chupa 2 ndogo za bia**
    c) **Zaidi ya glasi 2 za divai**
    d) **Zaidi ya tots/shot 2 za pombe kali**
    e) **Chupa 2 kubwa za bia**
    f) **Chupa 1-2 ndogo za bia**
    g) **Glasi 1-2 za divai**
    h) **Tots/shot 1-2 za pombe kali.**

Lishe (matunda na mbogamboga)

15. Je unakula matunda na mbogamboga?
    a) Ndio

b) Hapana

16. Je unakula matunda na mbogamboga mara ngapi kwa wiki?

weka v kama Ndio na X kama Hapana

	Kila siku	Mara mojamoja	Hali e
Matunda			
Mbogamboga			

17. Katika siku ya kawaida unakula sehemu ngapi za matunda?

a) Zaidi ya sehemu 5
b) Sehemu 3 hadi 4 kwa siku
c) Chini ya sehemu 3 kwa siku
d) Chini ya sehemu 1 kwa siku
e) Mara chache hula matunda

18. Katika siku ya kaaida unakula sehemu ngapi ya mbogamboga?

a) Zaidi ya sehemu 5
b) Sehemu 3 hadi 4 kwa siku
c) Chini ya sehemu 3 kwa siku
d) Chini ya sehemu 1 kwa siku.

Mazoezi ya mwili

Maswali yanayofuata yanahusu muda unaotumia wiki moja timilifu kufanya mazoezi ya mwili. Tunakuomba ujibu maswali haya hata hudhani kwamba hushughulishi mwili wako ipasavyo. Fikiria kwanza muda unaotumia kufanya kazi.

Shughuli unazozifanya ukiwa kazini

Fikiria kazi kama shughuli yoyote unayoifanya kwa malipo au bila malipo, kusoma au kupata mafunzo, kai za usafi nyumbani , kuvuna mazao,uvuvi au uwindaji kwa ajili ya chakula cha nyumbani, na kutafuta ajira.katika kujibu maswali haya ni vema kufahamu kwamba ‘kai ngumu’ ina maanisha kazi yenye kutumia nguvu nyingi na huongeza kasi ya mapigo ya moyo kwa kiwango kikubwa ‘kazi ngumu kiasi’ni zile zinazohusisha matumizi ya kiasi cha wastani ya nguvu na zinaongeza kasi ya mapigo ya moyo kwa kasi kidogo.

1. Je, kazi yako inahusisha ufanyaji wa kazi ngumu ambazo husababisha ongezeko kubwa la kasi ya mapigo ya moyo kama vile kunyanyua vitu vizito ,uchimbaji au shughuli za ujenzi angalau kwa dakika kumi bila kupumzika?
   a) Ndio
   b) Hapana (nenda namba 4)
2. Je shughuli zako zinahusisha kazi zinazo hitaji matumizi ya nguvu kiasi ambayo husababisha ongezeko dogo la kasi ya mapigo ya moyo kama vile kubaba vitu vyepesi kwa angalau dakika 10 bila kupumzika?
   a) Ndio
   b) Hapana (nenda namba 7)

3. Je ni siku ngapi katika wiki moja timilifu ambapo wewe hufanya kazi zinazohusisha matumizi ya nguvu kiasi kama sehemu ya kazi yako? Idadi ya siku……..
4. Je unatumia muda gani kufanya kazi zinazohitaji kiasi kidogo cha matumizi ya nguvu katika siku moja timilifu ya utendaji kazi wako? Masaa……..dakika……..

Sehemu inayofuata haitahusu kazi za kushughulisha mwili kama ambavyo umeeleza hapo awali . sasa ningependa kuuliza maswali kuhusu usafiri unaotumia kwenda sehemu mbalimbli. Kwa mfano kusafiri kwenda kazini , kununua bidhaa na kwenda kusali au kuabudu.

5. Je huwa unatembea au kutumia baiskeli (baiskeli ya kuendesha kwa pedeli za miguu) kwenda au kutoka maeneo mbalimbali kwa dakika 10 bila kupumzika?
   a) Ndio
   b) Hapana (nenda namba 10)

6. Katika wiki moja timilifu , je ni mara ngapi ambazo wewe hutembe au kuendesha baiskeli kwenda sehemu mbalimbali angalau kwa dakika kumi bila kupumzika? Siku……..

7. Je ni muda kiasi gani unatumia kutembea au kuendesha baiskeli kama njia ya usafiri katika siku moja timilifu? masaa…… dakika……..

Michezo na shughuli a kujistarehesha: maswali yanayofuata hayata husu njia za usafiri kama tulivyo kuulia hapo juu. Kwa sasa ningependa kukuulia kuhusu michezo, na shughuli za kujistarehesha.

8. Je wewe unacheza michezo yoyote au kufanya shughuli zozote za kujistarehesha za kutumia nguvu nyingi angalau kwa dakika 10 bila kupumzika ambazo huongeza kasi ya mapigo ya moyo kwa kiwango kikubwa?
   a) Ndio
   b) Hapana(nenda namba 13)

9. Je nisiku ngapi katika wiki moja timilifu ambazo wewe huwa unacheza michezo au unafanya shughuli za kujistarehesha inazohitaji matumizi ya nguvu nyingi?

   Idadi ya Siku….

10. Je katika siku moja timilifu huwa unatumia masaa mangapi kucheza michezo au kufanya shughuli za kujistarehesha zinazohitaji matumizi ya nguvu nyingi?

    Masaa…….
    Dakika…….

11. Je wewe unacheza michezo yoyote au kufanya shughuli zozote za kujistarehesha za kutumia nguvu kiasi angalau kwa dakika kumi bila kupumzika ambazzo huongeza kasi ya mapigo ya moyo kwa kiwango kidogo kama vile kutembea kwa haraka, kuogekea,kuendesha baiskeli na kucheza mpira wa wavu?
    a) Ndio
    b) Hapana (nenda namba 16)
12. Je ni siku ngapi katika wiki moja timilifu ambazzo wewe huwa unacheza michezo au kufanya shughuli za kujistarehesha za kutumia nguvu kiasi? Idadi ya siku……

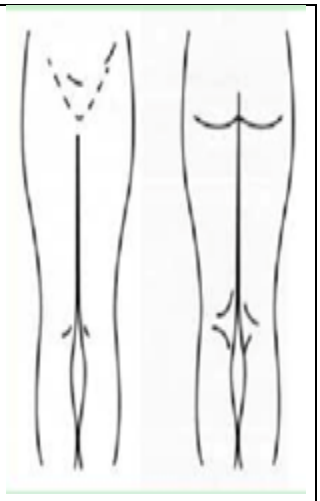
13. Katika siku moja timilifu huwa unatumia masaa mangapi kuchea michezo au kufanya shughuli za kujistarehesha za kutumia nguvu kiasi? Masaa……dakika……
14. Je una television(runinga) nyumbani?

a) Ndio
b) Hapana

15. Je wewe huwa unataama television (runinga) mahali kokote pengine?
    a) Ndio
    b) Hapana
16. Je kwa kawaida ni muda gani huwa unatumia kwa siku kukaa chini au kusimama kutazama television?
    Masaa……
    dakika……
17. Je una redio nyumbani?
    a) Ndio
    b) Hapana (nenda namba 21)
18. Kama jibu ni ndio. je kwa kawaida unatumia muda wa masaa mangapi kukaa chini au kusimama na kusikiliza redio kwa siku? Masaa ……. Dakika…….
19. Kwa kawaida huwa unalala kwa masaa mangapi kwa siku?.....

Dodoso la Edinburgh juu ya maumivu ya miguu (Claudication) (CAD/PVD)

A positive questionnaire diagnosis of claudication is made only if the correct answer is given to all questions

Na	Maswali	Jibu sahihi	
1.	Je unapata maumivu au usumbufu katika miguu yako wakati unatembea? Huwezi kutembea. Ikiwa umejibu ndio kwa 1 jibu maswali yafuatayo	ndio ( ) hapana ( )	
2	Je, maumivu hua yanaanza ukiwa umesimama au umekaa?	ndio ( ) hapana ( )	
3	Je, unapata ukiwa unapanda au kutembea kwa haraka?	ndio( ) hapana ( )	
4	Je, unapata ukiwa unatembea kwa kasi ya kiango cha kawaida?	ndio ( ) Hapana ( )	
5	Ni nini hutokea unapo simama ? • Huendelea kwa zaidi ya dakika 10? • Hutoweka ndani au chini ya dakika 10?	 ( ) ( )	
6	Unapata wapi maumivu haya au usumbufu? • Weka alama X kwenye mchoro sehemu hiyo.		

Mahitaji chanya ya claudication ‘Ndio’ kwa (1), ‘hapana’ kwa (2), ‘Ndio’ kwa (3), ‘Hutoweka ndani au chini ya dakika 10?’ kwa (5): gredi 1= ‘hapana’ kwa (4), gredi 2 = ‘Ndio’ kwa (4). Kufikia vigezo hivyo pamoja kuonesha alama.

Definite claudication: alama kwenye suli gimbi, **atypical claudication:** alama kwenye paja au kalio**No claudication**: hakuna maumivu kwenye suli gimbi, alama kwenye misuli ya paja, miguu, viungo yanayo tokea sehemu nyingine.

APPENDEX V: ETHICAL CLEARANCE

UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

OFFICE OF THE DIRECTOR - RESEARCH AND PUBLICATIONS

Ref. No.DA.282/298/01.C/ Date: 01/04/2021

MUHAS-REC-04-2021-541

Tuntufyege Erasto Mwasanjobe,
MSc in Physiology,
School of Medicine
MUHAS

RE: APPROVAL FOR ETHICAL CLEARANCE FOR A STUDY TITLED: Comprehensive assessment and characterization of the normal peripheral arterial parameters in young healthy black Africans in Tanzania

Reference is made to the above heading.

I am pleased to inform you that the Chairman has on behalf of the University Senate, approved ethical clearance of the above-mentioned study, on recommendations of the Senate Research and Publications Committee meeting accordance with MUHAS research policy and Tanzania regulations governing human and animal subjects research.

APPROVAL DATE: 01/04/2021
EXPIRATION DATE OF APPROVAL: 31/03/2022

STUDY DESCRIPTION:
Purpose:
The purpose of this cross-sectional study is to assess and characterize normal peripheral arterial parameters (ABI, TBI, and PVW) based on internationally established references, in young and healthy black Africans.

The approved protocol and procedures for this study is attached and stamped with this letter, and can be found in the link provided: https://irb.muhas.ac.tz/storage/Certificates/Certificate%20-%20520.pdf and in the MUHAS archives.

The PI is required to:

1. Submit bi-annual progress reports and final report upon completion of the study.
2. Report to the IRB any unanticipated problem involving risks to subjects or others including adverse events where applicable.
3. Apply for renewal of approval of ethical clearance one (1) month prior its expiration if the study is not completed at the end of this ethical approval. You may not continue with any research activity beyond the expiration date without the approval of the IRB. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.
4. Obtain IRB amendment (s) approval for any changes to any aspect of this study before they can be implemented.
5. Data security is ultimately the responsibility of the investigator.
6. Apply for and obtain data transfer agreement (DTA) from NIMR if data will be transferred to a foreign country.
7. Apply for and obtain material transfer agreement (MTA) from NIMR, if research materials (samples) will be shipped to a foreign country,
8. Any researcher, who contravenes or fail to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III section 10 (2)
9. The PI is required to ensure that the findings of the study are disseminated to relevant stake holders.
10. PI is required to be versed with necessary laws and regulatory policies that govern research in Tanzania. Some guidance is available on our website https://drp.muhas.ac.tz/.

Dr. Bruno Sunguya
Chairman, MUHAS Research and Ethics Committee

Muhimbili University of Health and Allied Sciences ★ DIRECTOR Research & Publications Box 65001

Cc: Director of Postgraduate Studies

9 United Nations Road; Upanga West; P.O. Box 65001, Dar Es Salaam: Tel. G/Line: +255-22-2150302/6; Ext. 1038; Direct Line:+255-22-2152489;Telefax:+255-22-2152489;E-mail:drp@muhas.ac.tz;Web:https://www.muhas.ac.tz

APPENDIX VI: INTRODUCTION LETTER

UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES
OFFICE OF THE DIRECTOR – POSTGRADUATE STUDIES

In reply quote;
Ref. No. HD/MUH/T.425/2019

15TH April, 2021

The Director,
Directorate of Undergraduate Education,
Muhimbili University of Health and Allied Sciences
P.O. Box 65001,
DAR ES SALAAM

Re: INTRODUCTION LETTER

The bearer of this letter is Dr. Tunfyege Erasto Mwasanjobe, a student at Muhimbili University of Health and Allied Sciences (MUHAS) pursuing MSc. Physiology.

As part of his studies he intends to do a study titled: "***Comprehensive Assessment and Characterization of the Normal Peripheral Arterial Parameters in Young Health Black Africans in Tanzania.***"

The research has been approved by the Chairman of University Senate.

Kindly provide him the necessary assistance to facilitate the conduct of his research.

We thank you for your cooperation.

Ms. Victoria Mwanilwa
For: DIRECTOR, POSTGRADUATE STUDIES

cc: Dean, School of Medicine, **MUHAS**
cc: Dr. Tunfyege Erasto Mwasanjobe

9 United Nations Road; Upanga West; P.O. Box 65001, Dar Es Salaam: Tel. G/Line: +255-22-2150302/6; Ext. 1015; Direct Line:+255-22-2151378;Telefax:+255-22-2150465;E-mail:dpgs@muhas.ac.tz;Web:https://www.muhas.ac.tz