Food Security, Anthropometric Status and Body Composition of People Living with HIV: A Case Study of HIV Positive Adults in Refugee Settlements in Uganda

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Figure 1.1 Bioelectrical Impedance Analysis (BIA) testing for one of the research participants in Kyaka Health Centre

Declaration

I, Robert Ntalo, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been appropriately indicated and referenced.

……

Ntalo Robert

Date: ……..

Dedication

This is for you Pamela, Emmanuel, Elijah, Ezra and Ethan. The many days and nights you endured my absence were not in vain! Your support, sacrifice and encouragement always motivated me to carry on. Thank you!

Abstract

Background and study objectives

Studies done to assess the prevalence and interaction of malnutrition, dietary practices, and food security among HIV positive refugees in Uganda are limited. There is also little information about the use of direct Bioelectrical Impedance Analysis (BIA) parameters for assessing or monitoring body composition among HIV positive adults in resource poor settings. The overarching goals for my study were: to assess the prevalence of HIV-related food insecurity and malnutrition, describe the body composition of HIV positive adults, and investigate the potential utility of using BIA parameters as prognostic indicators among HIV positive refugee adults.

Study methods and data collected

First, I conducted a cross-sectional study involving 368 HIV positive and 368 HIV negative adults recruited from two refugee settlements. Secondly, I conducted a prospective observational longitudinal study following up for 16 weeks 74 malnourished HIV positive adults who were attending a nutritional rehabilitation clinic as part of their routine HIV treatment and care. Data was collected on: the demographic characteristics and socioeconomic status of the participants; Individual Dietary Diversity and Household Food Insecurity; anthropometric indices; and Hand Grip Strength. I also collected bioelectrical impedance data – and used phase angle, resistance, reactance and bioelectrical impedance vector analysis – to assess the body composition of the participants.

Key results from the two studies

Overall, 57% of participants were food insecure with those from Nakivale being worse affected compared to those from Kyaka settlement – 75% and 38% of participants respectively. Multivariable regression indicated that HIV infection was not a risk factor to food insecurity but the participants' location significantly affected their food security status. 13% of the participants were underweight with those who were HIV positive more affected than those who were HIV negative – 15.2% compared to 10.3% respectively. HIV infection was found to be a risk factor for being underweight ($BMI \leq 18.49 kg/m^2$) with those infected with HIV being nearly three times of becoming underweight. Underweight male and female participants had significantly lower BIA values for phase angle, and reactance and resistance normalized for height. Malnourished HIV positive adults gained over 1.60kg of weight and 5Kg force for Hand Grip Strength during the 16 weeks of nutritional rehabilitation; males gained more weight and HGS compared to female participants. Phase angle, reactance and resistance normalized for height also increased during the 16 weeks of follow up but females participants had lower values.

Conclusion

Food insecurity and malnutrition are high among refugees in these areas of Uganda but due to a range of causes on top of HIV infection. Nutritional supplementation of malnourished HIV positive adults improves their nutritional status and BIA parameters. However, the gender variations observed need to be explored further.

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Finally, I wish to thank all the staff and colleagues at UCL Institute for Global Health (IGH), my family, relatives and friends and colleagues I have worked with in various organizations for your support and encouragement throughout these many years of my PhD studies.

List of Abbreviations and Acronyms

AHR	Adjusted Hazard Ratio
AIDS	Acquired Immune Deficiency Syndrome
AOR	Adjusted Odds Ratio
ART	Anti-Retroviral Therapy
ARVs	Ant Retro Viral (drugs)
BCM	Body Cell Mass
BIA	Bioelectrical Impedance Analysis
BID	Bioelectrical Impedance Data
BIVA	Bioelectrical Impedance Vector Analysis
BMI	Body Mass Index
BMR	Body Metabolic Rate
BWL	Body Weight Loss
cART	Combination Anti-Retroviral Treatment
CED	Chronic Energy Deficiency
CD4	Cluster of Differentiation type 4
CDC	Centers for Disease Control and Prevention
CFSVA	Comprehensive Food Security and Vulnerability Analysis
CI	Confidence Interval
CMI	Cellular Mediated Immunity
CSB	Corn Soya Blend
DDS	Dietary Diversity Score
DHS	Demographic and Health Survey
DRC	Democratic Republic of Congo
DXA	Dual X-ray Absorptiometry

EV	Exposure Variable
FANTA	Food and Nutritional Technical Assistance
FAO	Food and Agricultural Organisation
FBF	Fortified Blended Foods
FFM	Fat Free Mass
FFMI	Fat Free Mass Index
FFQ	Food Frequency Questionnaires
GAM	Global Acute Malnutrition
GIT	Gastro Intestinal Tract
GoU	Government of Uganda
GWG	Gestation Weight Gain
Hb	Haemoglobin
HBSS	HIV Behavioural Surveillance Survey
HC	Health Centre
HCCC	HIV Chronic Care Clinic
HEI	Healthy Eating Index
HIV	Human Immunodeficiency Virus
HFIAP	Household Food Insecurity Access Prevalence
HFIAS	Household Food Insecurity Assessment Scale
HNRP	HIV Negative Research Participants
HPRP	HIV Positive Research Participants
HRQL	Health Related Quality of Life
IDDA	Individual Dietary Diversity Assessment
IDDS	Individual Dietary Diversity Score
IDECG	International Dietary Energy Consultation Group

IDP	Internally Displaced Persons
IDU	Injection Drugs Users
IGH	Institute for Global Health
IM	Illness Marker
IMAM	Integrated Management of Acute Malnutrition
IRB	Institutional Review Board
ISS	Immuno Suppression Syndrome
Kg	Kilogram
LBW	Low Birth Weight
LMM	Lean Muscle Mass
LNMP	Last Normal Menstrual Period
LNS	Lipid Nutrient Supplements
LTM	Lean Tissue Mass
MAM	Moderate Acute Malnutrition
MCV	Mean Corpuscular Volume
MDG	Millennium Development Goals
MoH	Ministry of Health
MFBIA	Multi-Frequency Bioelectrical Impedance Analyser
MMHSS	Mean Mental Health Status Scores
MUAC	Mid Upper Arm Circumference
MUCHS	Makerere University College of Health Sciences
MUST	Malnutrition Universal Screening Tool
MUTH	Mbarara University Teaching Hospital
NGO	Non-Government Organisation
OPM	Office of the Prime Minister

OTC	Out-patients Treatment Center
OV	Output Variable
OVC	Orphans and Vulnerable Children
PA	Phase Angle
PHS	Physical Health Summary
PHSS	Physical Health Status Scores
PLHIV	People Living with HIV
PMTCT	Prevention of Mother To Child Transmission
PG-SGA	Patient Generated Subjective Global Assessment
PTB	Pulmonary Tuberculosis
RCTs	Randomized Control Trials
RNA	Ribonucleic acid
RUTF	Ready to Use Therapeutic Food
SD	Standard Deviation
SAM	Severe Acute Malnutrition
SGA	Subjective Global Assessment
SGPT	Serum Glutamate Pyruvate Transaminase
SOP	Standard Operating Procedure
SRP	Sexual Relationship Power
SSA	Sub-Saharan Africa
TASO	The AIDS Support Organization
TB	Tuberculosis
TBW	Total Body Water
TEM	Technical Errors of Measurements
UAC	Uganda AIDS Commission

UAIS	Uganda AIDS Indicator Survey
UCL	University College London
UNAIDS	The Joint United Nations Programme on HIV/AIDS
UNCST	Uganda National Council of Science and Technology
UNICEF	United Nations Children Education Fund
UNHCR	The Office of the High Commissioner for Refugees
USAID	United States Agency for International Development
UVRI	Uganda Virus Research Institute
VCT	Voluntary Counselling and Testing
WHO	World Health Organization
WFS	World Food Summit

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Structure of the thesis

I present this thesis in eight chapters as outlined below:

In *Chapter 1*; I provide an overview of the cross sectional and longitudinal research studies I conducted. I also provide brief background information related to HIV and malnutrition especially for People Living with HIV (PLHIV) aged 18 years and above. I state the problem statement and rationale of the study, study aims and objectives and the different hypotheses I explored for this study. I end the chapter with an outline of the two studies that I conducted.

In *Chapter 2*, I review the relevant literature focusing on issues related to HIV and Nutrition among PLHIV. This chapter has sections focusing on; the general HIV disease burden, the linkage of nutrition and HIV and the implications of each on the other, household food security issues and dietary practices and food intake among PLHIV. There are also sections on; anthropometric assessments used for screening and monitoring nutritional status of PLHIV and body composition measurements using Bioelectrical Impedance Analysis (BIA).

In *Chapter* 3, I describe the methods used in conducting the cross sectional and longitudinal studies. I present a description of the different study sites, key study variables and data sets, sample size estimation and how research participants were recruited for the two studies. I also provide the data management and analysis processes and quality control measures used, and ethical considerations and approvals that were granted for this research work.

In Chapters 4, I present the results for the cross sectional study based on the research questions for the study and then discuss these results in Chapter 5. In Chapter 6 and 7, I present the results from the longitudinal study and the discussion of the same respectively. In Chapter 8, I provide the conclusions from the two studies, limitations, how the results could improve the management of PLHIV and possible future research considerations in relation to the results from the two studies.

Chapter 1. Introduction and objectives

1.1 Introduction

The “slim disease”! This term was used in Uganda in the early 1980s to describe a ‘strange’ disease whose sufferers mainly presented with severe wasting, which made them look like 'skeletons' before they died [1]. Wasting and weight loss were reported from the beginning of the epidemic as common features of Human Immunodeficiency Virus (HIV) infection with nearly 80% of adults diagnosed with HIV infection being severely wasted. Hence, the initial World Health Organization (WHO) *Bangui* case definition for diagnosing symptomatic HIV infection and Acquired Immune Deficiency Syndrome (AIDS) in adult Africans included 'unintentional’ loss of more than 10% of someone's weight as a major sign for HIV with wasting, which was later referred to as an AIDS defining illness [2-8].

Malnutrition, weight loss, and wasting have still remained hallmarks of HIV disease since the beginning of the AIDS epidemic [9]. Severe malnutrition among People Living with HIV (PLHIV) is recognized as the “wasting syndrome,” which according to the Centers for Disease Control and Prevention (CDC) is defined as ‘body weight loss equal to or greater than 10% with associated fatigue, fever and diarrhea unexplained by another cause’ [10].

In Uganda, HIV and AIDS still remain significant public health problems and leading causes of disease and death according to estimates done by Hladik et al [11]. HIV prevalence peaked to around 18.5% in the 1980s, and then fell to 6.5% in 1995 stagnating at this level for nearly 10 years until 2005 [12]. The 2011 Uganda AIDS Indicator Survey (UAIS) showed HIV prevalence of 7.8% which was also reported in The Joint United Nations Programme on HIV/AIDS (UNAIDS) 2014 report, despite the overall global reductions noticed in HIV infections and AIDS related deaths over the past decade [13-19].

Uganda is a host to many refugees and asylum seekers from several countries. According to the United Nations High Commissioner for Refugees (UNHCR), by August 2012, Uganda was hosting about 190,000 registered refugees and asylum seekers. These registered refugees [1] are mainly hosted in the districts of Insingiro (Nakivale and Oruchinga settlements) and Kyegegwa (Kyaka II settlement) both found in the South-western part of the country. A small number of refugees are staying in other districts in the Northern part of the country [20]. In most cases, refugee settlements are surrounded by villages where the host (national) populations live. The set-up of these settlements makes it possible for the free movements, economic and social interactions between refugees and nationals.

During the period 2007 to 2008, HIV prevalence studies conducted in Kyaka and Nakivale settlement by the Uganda Virus Research Institute (UVRI) and the UNHCR / Great Lakes Initiative on HIV/AIDS estimated the HIV prevalence among refugees to be 7.6% and 5.7% respectively [21]. In comparison, estimates from UAIS 2011 report for the Western and Southwestern regions of Uganda where the two settlements are found were 6.9% and 5.9% respectively [13]. This indicates a significantly higher HIV prevalence in Kyaka compared to the regional average. Access and utilization of HIV and AIDS services among the refugees is also low as observed among many Ugandans (host populations) [17-19]. For instance, according to O'Laughlin et al, she and her colleagues showed that during the time when HIV prevalence surveys were conducted in the two refugee settlements, there were only 659 People Living with HIV/AIDS (PLHIV) who attended the Nakivale HIV clinic. The 659 PLHIV translates into 1.2% of the settlement population at that time, compared to the estimated HIV prevalence of 6.9% within the settlement [21].

[1] There are claims from health care providers and refugee leaders that there are many unregistered refugees staying with relatives or friends within the refugee settlements.

According to the World Health Organisation (WHO) 2005 technical consultation report, several researchers agreed that malnutrition plays a significant and independent role in the morbidity and mortality of PLHIV, and have suggested that ensuring good nutrition is a fundamental part of caring for PLHIV in maintaining their health and quality of life [22]. Studies have shown that even in the era of ART, malnutrition remains common and associated with increased risk of death and poor treatment outcomes in developed and resource constrained (developing) countries. The situation is worse in developing countries especially in settings where poverty and food insecurity are more prevalent [23,24].

Refugee populations are potentially vulnerable to becoming food insecure and hence susceptible to malnutrition [25]. Usually they have limited land for growing adequate food stuffs to feed themselves and their families and not enough money to purchase the food they would want to eat with such kinds of circumstances and living conditions making refugees food insecure and unable to eat nutritious foods [26]. It is possible that such vulnerability and lack of enough food might be worsened among refugee households whose members are infected or affected by HIV or other chronic infectious diseases.

Food insecurity has been found to compromise sustained ARV therapy in resource poor settings in several ways [27,28]. In some instances, patients taking ARVs report having increased appetite leading to intolerable hunger, with some of them believing that they should skip some doses of the drugs or not start on ARVs at all when they cannot afford the added nutritional burden [29,30]. Other reports indicate patients experiencing exacerbated side effects of ARVs in the absence of food, and in some cases competing demands between costs of food and medical expenses have led to patients either defaulting from treatment, or giving up food and wages to get medications [31-32]. In addition, there are reported cases of patients forgetting to take their medications because of working long hours in the field

looking for what to eat [28,33]. All this information shows that there is hence an observed relationship between food insecurity and adherence to HIV treatments which calls for the need to investigate the levels of food insecurity among HIV positive adults living in refugee settlements.

Body Mass Index (BMI) and Mid Upper Arm Circumference (MUAC) are the mainly used indicators for anthropometric assessment, for screening and monitoring nutritional status of adults and children. However, these anthropometric indicators have some limitations especially in measuring the fat and lean mass of an individual hence the suggestion of using Bioelectrical Impedance Analysis (BIA) [34,35]. From the reviews I did, I found that BIA is one of the methods being used in resource rich countries for research work and clinical care for assessing the body composition of malnourished patients, but its use is still limited in resource poor settings [36,37].

Bioelectrical impedance analysis does not measure body composition directly but through using appropriate predictive regression equations to estimate Total Body Water (TBW), Free Fat Mass (FFM) and Body Cell Mass (BCM). The unavailability of population reference predictive equations and inability to control changes in hydration status especially among people who might be having varying illnesses led to the suggestion to use raw bio impedance data - Phase angle (PhA), Resistance (R), Reactance (Xc) normalised by height in R/Xc graphs using Bioelectrical Impedance Vector Analysis (BIVA) [38-41]. The use of raw bio impedance data provides information on the hydration status and body cell mass and cell integrity which have proven to be of prognostic value in various diseases including HIV and AIDS [42].

During my literature search I found few studies using direct BIA data like phase angle, reactance and resistance normalized by height in R/Xc graphs used in the assessment and

monitoring nutritional status or clinical management of malnourished HIV positive adults in resource poor settings like Uganda. The use of BIA data is still limited, but considering its convenience, effectiveness and easiness in using it, there is need to explore its usage in resource poor settings for assessing and monitoring the nutrition and health status of HIV positive adults and how it can complement other available methods.

1.2 Problem statement

People Living with HIV are advised by health care providers to adopt healthy behaviours, one of such is eating balanced diets in order to meet their increased protein and energy needs to maintain good nutritional status. This is part of the nutritional counselling PLHIV are supposed to receive from health care providers whenever they attend the HIV chronic care clinics as part of their comprehensive health care and support [43].

Several studies have been conducted where levels of malnutrition among HIV-positive adults have been documented [44-47]. But, currently, despite their vulnerabilities, there are still few studies that have specifically investigated issues concerning malnutrition among adult HIV-positive refugees. This calls for an urgent need to understand how access to food and dietary practices affect the nutritional status of HIV positive adults, especially refugees, who may be depending on food assistance (food aid) and may not have enough land to produce adequate food for themselves and their family members. This "double" vulnerability (inadequate food supply and increased body energy demands due to HIV disease status) among HIV-positive adults needs to be critically investigated especially among the refugee populations.

Bioelectrical impedance data is being used in resource rich countries for assessing body composition among patients with different disease ailments. There is still limited literature

regarding the usage of BIA data in resource poor settings especially to assess and monitor nutritional status and body composition among HIV-positive adults [37]. The usefulness of using BIA in assessing and monitoring nutritional status and body composition among malnourished HIV-positive adults and those who are at risk of getting malnourished needs to be explored, and understanding the changes in the BIA indices of malnourished HIV positive adults may be useful in the management of their nutritional and clinical status.

It should be noted that knowing the prevalence of malnutrition among HIV-positive adult refugees is crucial; and investigating what impact and effect dietary practices and access to food have on the nutritional status of these vulnerable populations is essential. At the same time, knowing and describing the BIA parameters of HIV positive and HIV negative adults is important in the use of BIA as a method for assessment and monitoring of the body composition of PLHIV as it could provide another possible alternative and option in the nutritional management of such group of people. The knowledge gained from this research could lead to the development and implementation of more effective intervention programmes for HIV positive refugees and also enable health workers to provide focused nutritional health messages, support and care as may be needed, and provide possibilities of using BIA parameters in assessing nutrition and clinical status of PLHIV.

1.3 Study aims and objectives

1.3.1 Study aims

The aim of the study was twofold; to assess the prevalence of HIV-related food insecurity and malnutrition and describe body composition of HIV positive adults, and secondly, to investigate the potential utility of using Bioelectrical Impedance Analysis (BIA) parameters

in screening and monitoring nutritional and physical status of HIV-positive adults in a resource poor setting.

1.3.2 Specific study objectives

There were five specific objectives for this research study;

1. To assess and compare malnutrition prevalence and body composition indices for HIV positive and HIV negative adults living within the same communities in Uganda.
2. To investigate the relationship between household food insecurity and nutritional status among HIV positive and HIV negative adults.
3. To investigate the relationship between nutritional status and functionality among HIV positive and HIV negative adults.
4. To describe and quantify the changes in the nutritional status and body composition indices of malnourished HIV positive adults receiving nutritional supplementation during a 16 week follow up period.
5. To investigate how changes in functionality vary with changes in nutritional status during 16 weeks of nutritional rehabilitation.

1.4 Study hypotheses

There were five hypotheses tested - three for the cross sectional study and two for the longitudinal study as outlined below:

Hypothesis for the cross sectional study

1. HIV infection is a risk factor for food insecurity among adult residents of refugee settlements in Western Uganda.
2. HIV infection is a risk factor for malnutrition among adult residents of refugee settlements in Western Uganda.

3. HIV infection is associated with differences in bioelectrical impedance parameters among adult refugees in settlements in Western Uganda.

Hypotheses for the longitudinal study

4. The functionality of malnourished HIV positive adults, as measured by Hand Grip Strength (HGS), improves during nutritional therapy and is correlated with changes in bioelectrical impedance parameters
5. Changes in weight or MUAC are correlated with changes in bioelectrical impedance parameters in malnourished HIV positive adults during nutritional therapy.

1.5 Scope of the research study

1.5.1 Research study components

This thesis is based on two major research studies which made-up my PhD research; (a) cross sectional observational study for known HIV positive and 'confirmed' HIV negative adults, and (b) longitudinal observational study involving malnourished HIV positive adults undergoing nutritional rehabilitation in Kyegegwa Health center IV (referred to as Kyegegwa longitudinal study).

1.5.2 Overview of data collected for the two study components

I collected data on seven major issues; (a) demographic and socioeconomic characteristics of the participants, (b) self-reported health status of participants in the past four weeks prior to the interviews, (c) anthropometric measurements, (d) 24 hour dietary recall, (e) household food insecurity access based on the past four weeks (f) body composition as measured by BIA data – phase angle, resistance and reactance normalised by height in the R/Xc graphs using BIVA and (f) Hand Grip Strength (HGS) measurements of participants. I provide a detailed description of the process of data collection (methods) in chapter 3 while the results are in chapter 4 for the cross sectional study and chapter 6 for the longitudinal study.

Chapter 2. Literature review

2.1 Introduction

In this chapter, I present the literature review I carried out in relation to the key issues I explored in the two research studies for my thesis. The information I provide mainly focuses on issues related to nutrition in the context of HIV infection among adults living in resource poor settings. Here, I summarise this information and present it in seven broad sections, which make up this chapter.

First, I provide some general background information highlighting the current trends of HIV and AIDS and in particular its burden - in terms of deaths and morbidity on the people within Sub-Saharan Africa (SSA). In section two, I provide information about the relationship between nutrition and infectious diseases. Section three focuses on nutrition and HIV with highlights of studies about the prevalence of malnutrition among HIV positive adults, methods commonly used in assessing, monitoring and screening for the nutritional status of HIV positive adults especially in resource poor settings.

In the fourth and fifth sections, I review the causes of malnutrition among people living with HIV, mainly focusing on dietary practices and food intake and household food security. I also reviewed studies that show the association of food security and dietary practices and food security, dietary practices / food intake and poor nutritional status especially among HIV positive adults.

Section six focuses on the use of BIA in assessing body composition among HIV positive adults and other people suffering from chronic diseases. I conclude this chapter with a summary indicating the key issues raised from the studies and information that I reviewed, and then link this information to the research questions which I investigated for my study.

2.2 HIV and its burden in Sub-Saharan Africa (SSA)

2.2.1 Deaths due to AIDS

According to the 2014 UNAIDS Report on the global AIDS epidemic, AIDS-related mortality in Sub-Saharan Africa (SSA) declined by 32% from 2005 to 2013, but the region still accounted for 70% of the nearly 1.8 million people that died of AIDS in 2013. In the same report, it is mentioned that in many countries, the increased availability of ART and improved care for PLHIV has been key to the reduction in mortality although only 54% of those eligible for treatment had access to antiretroviral drugs by the end of 2012 [48]. Similarly, according to the Global Burden of Disease Study (GBDS) 2010 report; HIV/AIDS still remained a leading cause of disease burden and death in many countries in SSA despite major declines in AIDS-related mortality due to fewer new HIV infections and the increased availability of antiretroviral therapy, care, and support [49]. Statistics from the GBDS and the European Observational Cohort Collaboration report on mortality among HIV-infected adults show that there are still many deaths occurring among HIV positive adults in SSA compared to those in Europe [42,43]. This is reported to be a reflection of the kind of care and support PLHIV receive or may not be receiving.

In their paper "AIDS is not over," Sidibe and colleagues acknowledged that a great deal of work had been done in containing the HIV and AIDS scourge. But to sustain the gains achieved so far, they also rightly urged for the continued availability of more funds and investment towards the implementation of HIV/AIDS activities, the strengthening of the health sector and health systems to promote universal health coverage and access to HIV and AIDS services as well as increased community participation and political leadership [51]. Similar observations and thoughts were also made by other researchers like Quarraisha et al, in the different commentaries they made, in which they reviewed the current status and

challenges to the global HIV epidemic [52-54]. Although they did not mention specific areas of focus, they however suggested continued investments in HIV prevention, treatment and care programmes to reach out to more people, especially those in resource poor countries who do not have access to available HIV and AIDS prevention and treatment services.

2.2.2 HIV/AIDS in Africa's Great Lakes Region

Within Africa's Great Lakes region[2], only Rwanda and Burundi with 3% and 3.3% HIV prevalence rates respectively were reported in the Global UNAIDS report 2013 as having achieved a significant decline of HIV infections in 2012. In addition, other reports show that Rwanda has already met Millennium Development Goal (MDG) 6: to halt and begin to reverse the HIV epidemic by 2015. The rest of the countries, such as Uganda, Democratic Republic of Congo (DRC), Tanzania, and Kenya, have shown less reductions in the prevalence of HIV [55]. In Uganda the HIV situation is even more worrying. The UNAIDS 2012 report showed that Uganda's HIV prevalence increased by 22% in 2011 compared to the 2001 figures - 6.9% to 7.2% HIV prevalence rates respectively [14].

As of January 2012, Congolese refugees constituted nearly 80% of all the refugees that were staying in Nakivale and Kyaka refugee settlements, with the rest being Rwandese, Burundians and Somalis [20]. Although the national HIV prevalence in DRC is estimated at around 4.0% (according to the 2012 DHS report), however one study conducted in the Eastern parts of the country showed higher HIV prevalence rates which are far above the Congolese national average [56]. Furthermore, another study conducted by Kim AA in 2009 among 1,284 internally displaced women and women residing along the Congo River in the DRC, had found an HIV prevalence of 3.1% (95% CI 2.1%, 4.1%) among women in the

[2] Countries in Africa's great lakes region include: Uganda, Rwanda, Burundi, Democratic Republic of Congo, Tanzania, Kenya and South Sudan.

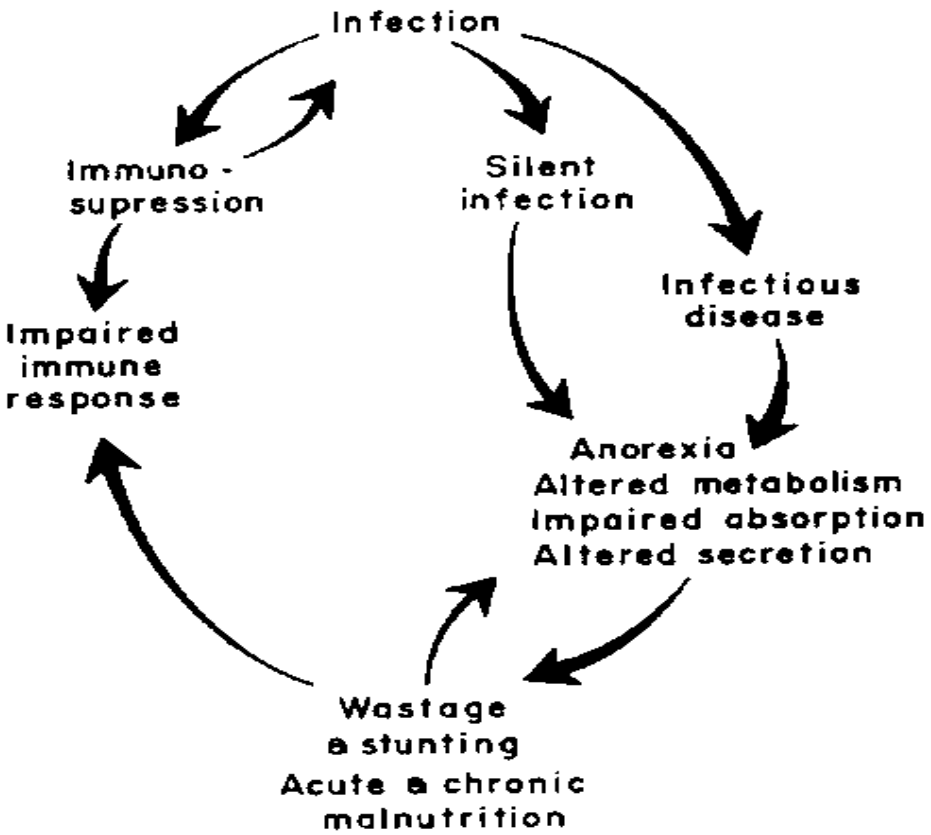
Congo River population and HIV prevalence of 7.6% (95% CI 4.1%, 11.0%) among internally displaced women [57]. The effects of war resulted in increased sexual violence against women, inadequate availability of HIV prevention and treatment services, and poor health care services in general were mentioned as some of the key reasons for the high HIV prevalence among Internally Displaced Population (IDPs) [58]. It has to be noted that, in most cases it is people who have already been internally displaced by war that eventually cross over to Uganda as refugees to escape the war and conflicts that have been going on in DRC for more than a decade.

2.3 Nutrition and its relationship with infectious diseases

The interaction of nutrition and infectious diseases has long been known by various health scientists with Krawinkel noting in one of his papers that food was being used as an integral part of the management of infections during the time when antibiotics were not yet available [59]. This interaction has also since the 1960s been described as 'synergistic' according to the WHO monograph series written by Scrimshaw and colleagues in which they strongly argued that; malnutrition is involved in reducing resistance to infection, and that infection, in turn, negatively affects the nutritional status of an individual [59,60]. In their nutrition policy discussion paper on malnutrition and infection, Tomkins and Watson used the term "malnutrition – infection complex" to point out that; "malnutrition increases the risk and worsens the course of infectious diseases; and infection leads to malnutrition" [61]. There have also been other observations done in various clinical settings which further demonstrated the linkage between under-nutrition and higher risk of infections among people of different age groups [62,63].

It has been urged that resistance to infection is determined by many interrelated factors, but one of the most significant variables is the nutritional status of the host [62]. Malnutrition has been observed to increase susceptibility to diseases like measles, tuberculosis (TB), leprosy, diarrhoea, respiratory infections, malaria, and more recently the progression of HIV to AIDS and death [63,64]. It has been observed among people infected with TB that malnutrition profoundly affects Cell Mediated Immunity (CMI), and it is this CMI which is the principle host defence against TB while the association of malnutrition and other various infectious diseases like malaria, schistosomiasis and geohelminth infections has been demonstrated [65-68]. The pathways of the impact and interaction of infectious diseases and nutritional status is graphically shown below in Figure 2.1.

Figure 2.1 Interaction of infection and malnutrition[3]



[3] *Adapted from Mate (1990, 1992), downloaded from: http://www.nzdl.org/gsdlmod?e=d-00000-00---off-0fnl2.2--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00&a=d&cl=CL2.8&d=HASH0107daed034a13c3be52f68f.6.*

2.4 Nutrition and HIV

Like many other infectious diseases, the link between nutrition and HIV has been observed both in rich and resource poor countries showing that poor nutritional status among PLHIV is still a common occurrence not only before the advent of ART but even after many PLHIV have gotten access to / or had been initiated on HAART [22,69]. The nutritional consequences of HIV where those infected became severely wasted (malnourished) was one of the common features of HIV/AIDS disease and led to it being named and termed as the 'slim disease' in Uganda and many other African countries [1,2].

The effect of nutrition on HIV and vice versa in many sub-Saharan African countries has been noted; as a significant proportion of PLHIV are from countries which at the same time suffer from high rates of chronic malnutrition [9,17]. This information suggests that many of those PLHIV might be malnourished or suffer from the effects of under-nutrition even before they became infected with HIV.

2.4.1 Prevalence of malnutrition among HIV infected adults

van Lettow and colleagues conducted a cross sectional study in Malawi among 579 HIV positive and 222 HIV negative adults between July 1999 and April 2003. They studied the association of wasting, micronutrient malnutrition and HIV viral load among patients with Pulmonary Tuberculosis (PTB), and found out that; more than half of the study participants (59%) were wasted with BMI <18.5kg/m^2 [70]. Similarly in Nigeria, a cross sectional study conducted by Obi et al between July 2007 and June 2008 among 120 HIV infected and 120 HIV negative adults using the Subjective Global Assessment (SGA) method observed that 80.8% of HIV patients were malnourished with 32.5% being severely malnourished. This was in contrast with 15% mild to moderate malnutrition rate observed among HIV negative adults, with none having severe malnutrition [71]. Although the number of participants

compared in this study was small and malnutrition was only measured by SGA (no information on BMI measurements were provided in the study report) the results showed a higher prevalence of malnutrition among HIV infected study participants compared to their peers who were HIV negative.

In another cross sectional descriptive study done among six support groups in Gaborone, Botswana, between June and December 2008, Nayepi examined the proportion of 145 PLHIV at risk of getting malnourished. He reported that almost 50% of the study participants were at risk of developing malnutrition, while 30% were malnourished with a BMI < 18.5kg/m2 [72]. Koethe et al observed similar prevalence of malnutrition (33% with a BMI <18.5kg/m^2) among a large cohort of 40,778 HIV infected adults that were being initiated on ART in Lusaka in a study conducted between May 2004 and April 2008 [73]. The prevalence of malnutrition observed by Koethe was higher compared to that observed by Olalekan when he conducted a meta-analytical analysis using Demographic and Health Survey (DHS) data sets from 11 countries (Burkina Faso, Cameroon, Ethiopia, Ghana, Guinea, Kenya, Lesotho, Malawi, Rwanda, Senegal and Zimbabwe). He estimated HIV-related malnutrition among HIV positive women of 10.3% (95% CI 7.4% to 14.1%) [74]. .

The prevalence of malnutrition among HIV positive adults is also a common feature even among HIV positive adults living in countries other than those in sub-Saharan Africa. Hu et al, used a number of different methods; Subjective Global Assessment (SGA)[4], Malnutrition Universal Screening Tool (MUST), Body Mass Index (BMI), food frequency questionnaire and dietary records, to evaluate malnutrition among 94 HIV positive hospitalised patients in urban Chengdu. They observed that malnutrition ranged from 37.2% by BMI to 77.2% by SGA, and insufficient total energy and protein intake was recorded at 59.5% and 54.3%

[4] Subjective global assessment (SGA), is a clinical technique which assesses the nutritional status based on features of the history and physical examination.

respectively [75]. Although the number of these study participants was smaller compared to those studies conducted in Africa and these (study participants) were hospitalized patients who might have been very sick, the results indicate comparable rates of malnutrition prevalent among HIV positive adults despite the different continental locations. Similar results of malnutrition among HIV positive adults were also shown in Paton's study conducted in Singapore among 394 HIV positive hospitalised adult patients that were being initiated on ART. He observed malnutrition rates of 16% and also showed that malnutrition was a key predicator for the treatment outcome after 12 months of starting ARVs [33].

Several studies have shown that wasting and malnutrition are common occurrences among those infected with HIV. Malnutrition is thought to even occur from the onset of HIV infection, although more commonly during the late stages of the disease. The loss of even less than 5% of the baseline body weight is said to have an adverse impact on the outcome of HIV infection [76,77]. Because of this, assessing and monitoring the nutritional status (routine nutritional follow-up) is important in the management and well-being of PLHIV.

Niyongabo et al compared different methods for assessing nutritional status among 88 HIV infected adults. They observed malnutrition among 22.4% of the subjects using SGA, and 37.1% based on Body Weight Loss (BWL). They also noted that SGA rapidly detected a worsening status of poor nutrition while BWL detected malnutrition at an earlier stage. A good correlation was found between SGA class (normal, mild or moderate and severe malnutrition) and body composition assessed by anthropometry and BIA [78]. Other studies where SGA has been used independently or with other methods for assessing nutritional status among HIV infected adults have also been described [76-78]. However, in a study conducted by Mokiri et al among 217 HIV patients from The AIDS Support Organisation (TASO) in Uganda, they questioned the sensitivity of Patient Generated Subjective Global

Assessment (PS-SGA) for determining the nutritional status of HIV infected adults. Based on the results of their longitudinal study, they noted a high prevalence of malnutrition in the study group using different methods of nutritional assessment. But overall, they concluded that the PG-SGA tool did not adequately discriminate between underweight and normal subjects and hence was not reliable enough for assessing nutritional status in that population of HIV-infected adults [79].

It has been noted that anthropometric measurements provide an inexpensive and non-invasive means of assessing and monitoring nutritional status of adults, and also assist in the screening for their nutritional risk. The techniques and equipment used are relatively simple but they require regular checking and careful training of the people that are involved in taking the anthropometric measurements to ensure accurate and reproducible measurements [80]. Weight, height and BMI are usually taken for HIV positive adults. The use of BMI to identify malnutrition was further confirmed as a measure of Chronic Energy Deficiency (CED) by the International Dietary Energy Consultation Group (IDCG) in 1986, and WHO has since recommended its use [81]. Serial weight measurements and subsequently BMI, was used by CDC to identify the wasting syndrome and to predict the development of AIDS [10]. A low body mass index (BMI $\leq$ 18.49 kg/m^2) has since emerged as a useful indicator of a poor nutritional status.

2.4.2 Effects of malnutrition on the progression of HIV disease including morbidity, mortality and functionality of HIV-positive adults

Malnutrition is thought to be one of the cofactors that affect immune-competence, and contributes to metabolic dysfunctions, which then lead to progression of HIV disease, and with the reduced immunity thought to then lead to increased susceptibility to infections, leading to energy loss to the individual and reduced productivity [22].

Several studies have documented the strong relationship between nutritional status and poor HIV outcomes among HIV infected adults. In one of these studies conducted by Liu et al, they examined the association between nutritional status, represented by BMI, MUAC, haemoglobin (Hb) concentrations at ART initiation, and death in the first 3 months of ART. They also investigated the changes in weight, MUAC, and Haemoglobin concentrations by 3 months after ART initiation in relation to the risk of death 3–6 months, 6–12 months among 18,271 HIV infected adults from clinics in Dar es Salaam in Tanzania. They observed poor nutritional status at ART initiation and decreased nutritional status in the first 3 months of ART as being strong independent predictors of mortality [82].

In another multi-country, multi-site study conducted by Palombi et al, which involved 3,749 HIV patients from Mozambique, Malawi and Guinea who were starting ART treatment, they showed that survival after 6 months was associated with baseline BMI and haemoglobin levels [80]. Similar findings in relation to mortality, where a low BMI at the start of ART was shown as being an independent predictor of early mortality have been observed in several other countries in SSA. For example, in Zambia patients that started with a BMI <16.0 kg/m^2 had twice the risk of death compared their peers with BMI >16.0 kg/m^2 [81]. In rural Malawi, patients who initiated ART with a BMI of ≤ 15.9 kg/m^2 had six times more risk of death at three months compared with those with a BMI ≥ 18.5 kg/m^2 [83].

Weight loss is not only associated with death but also with the occurrence of various opportunistic infections as well, as was observed in a study of a prospective cohort of 3,389 Tanzanian adults initiating ART who had been enrolled in a multivitamin trial [84]. It was observed that weight loss as early as one month could be used to identify adults at risk of adverse outcomes. Study participants with ≥ 2.5% weight loss had 6.43 times (95% CI: 3.78, 10.93 times) the hazard of mortality with that of participants with weight gains ≥ 2.5%, if

their baseline BMI was ≤ 18.5 kg/m^2 but only 2.73 times (95% CI: 1.49, 5.00 times) that hazard of mortality if their baseline BMI was ≥ 18.5 and < 25.0. The weight loss at one month was also associated with other opportunistic infections [84].

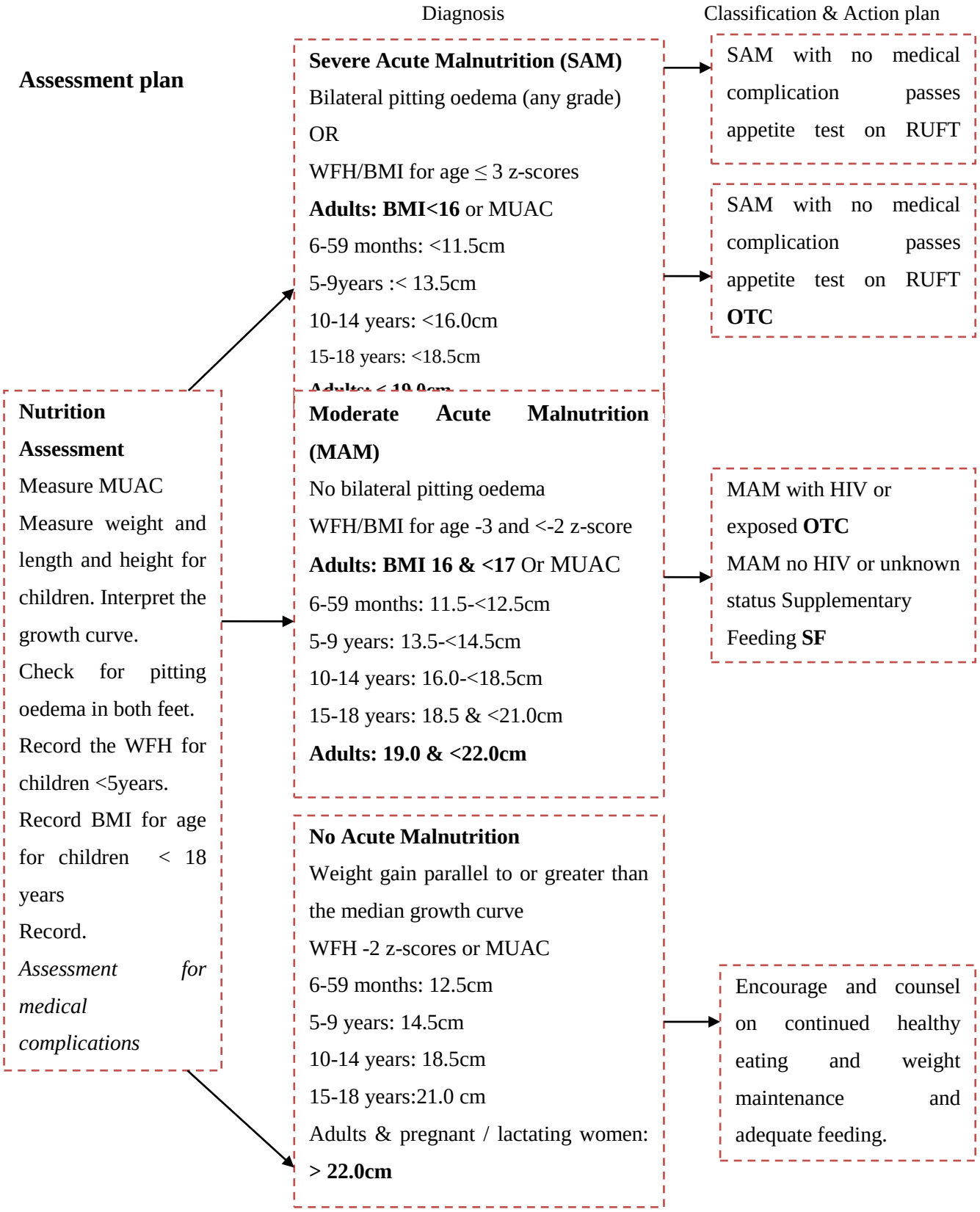
Food insecurity and malnutrition among HIV infected adults have been not only associated with possible deaths and poor effect on patients' recovery through increased morbidities, but also observed to escalate the potential for sexual and vertical transmission of HIV with the lack of adequate food supplies possibly leading many women and men into engaging in inappropriate sexual behaviours [85]. Poor nutritional status of HIV positive pregnant mothers has been shown to be associated with poor pregnancy outcomes, and similarly HIV positive breastfeeding mothers who were malnourished had frequent poor health status compared to those who were HIV negative [86,87].

Apart from other health and nutrition problems, there are studies done in resource rich countries, which have shown that there are impairments in physical function and frailty among HIV-infected adults [24]. It has been reported that wasting and particularly the loss of metabolically active lean muscle mass may be responsible for the reduction in functionality among HIV-infected adults [88].

2.4.3 Management of malnutrition among HIV infected adults

It is thought that even in the early stages of HIV disease when there are no apparent symptoms; HIV puts a lot of demands on the body's nutrition status hence the risk of getting malnourished any time during the illness [27]. For this reason, WHO guidelines on management of malnutrition among PLHIV encourages policy makers and health care workers to provide nutrition and food support to PLHIV as part of the comprehensive care to reduce their risk of becoming malnourished [89].

Figure 2.2 Algorithm for nutrition assessment and classification for Uganda[5]



[5] *Adapted from Uganda's Ministry of Health Guidelines for Integrated Management of Acute Malnutrition*

The Ministry of Health in Uganda developed an algorithm for use in the management of acute malnutrition among HIV infected adults. The algorithm is highlighted in **Figure 2.2 above** and involves: first, conducting nutritional assessment based on the patient's history and physical examination including carrying out appropriate anthropometric measurements (weight, height and MUAC). Secondly, making an appropriate diagnosis (nutritional status), and lastly, taking the appropriate management and action plan based on the person's nutritional status [90]. Training manuals and guidelines for management of malnutrition among people living with HIV are available in many health facilities within Uganda with such These manuals provide the relevant information which health care providers use for the nutrition management and care for PLHIV.

2.4.3.1 Nutrition supplementation and the use of Ready to Use Therapeutic Foods (RUTF)

There are reports that nutritional supplementation has become part of the comprehensive care for HIV positive malnourished patients either starting ART or those that are not yet started on ART, in many countries in sub-Saharan Africa [91]. It is urged that this is done although there is still limited evidence for supporting nutritional interventions among HIV positive adults [92]. However, several countries including Uganda have developed guidelines that are used for the management of malnutrition and more specifically the provision of food supplementation for people infected with HIV as illustrated in the guidelines for Integrated Management of Acute Malnutrition (IMAM) among adults [92].

There are both macronutrient and micronutrients food supplements and different therapeutic foods which are being used in the management of acute malnutrition among HIV infected adults [93]. The commonly used therapeutic foods in SSA include: Corn Soya Blend (CSB), several

Ready to Use Therapeutic Foods (RUTF) like Plumpy'Nut® and "RUTAFA[6]", Lipid Nutrient Supplements (LNS) and Fortified Blended Foods (FNF). These food supplements use a mixture of different ingredients with formulations including: powdered milk, peanut butter, vegetable oil, sugar, and a mix of vitamins, salts, and minerals. The potential advantage of this food are the low percentage of free water and the high energy and nutritional density [94,95]. In Uganda, the Ministry of Health recommends the use of Plumpy'Nut®, which is a locally produced Plumpy'Nut like-product referred to as "RUTAFA" with similar nutrient composition based on the locally produced food products.

2.4.3.2 Nutritional supplementation associated with improved recovery among malnourished HIV positive adults

Some studies have shown that RUTF increases the chances of nutritional recovery among HIV infected adults [96]. Ahoua et al, evaluated the outcomes of 1,340 of 8,686 HIV infected adults who had started ART, and enrolled into the nutrition programmes in three clinics in Kenya and Uganda. After four months of follow up, they observed that concomitant administration of ART and RUTF increased the chances of nutritional recovery although there were 48% of the patients that did not respond to nutrition therapy. This might suggest apart from nutrition, there other requirements needed for HIV infected adults to promote full nutritional recovery [97].

The synergetic effect of nutrition and HAART was also documented in another study conducted in Mozambique among 104 HIV infected adults. Two cohorts were studied, one which had HAART only and another with HAART and food supplementation. Substantially higher and significant increase in BMI levels were observed in the cohort that received HAART and food supplementation [98]. Similarly, nutritional supplementation was also associated with reduction in weight loss among HIV infected breastfeeding mothers in Malawi who were receiving a lipid nutrient supplementation [99].

[6] This is a locally produced RUTF which has been named RUTAFA by the patients. http://www.reco-industries.com/index.php/thereputical-food

Food supplementation among PLHIV has been associated with better adherence to antiretroviral therapy as was shown by Cantrell et al, in a study conducted among 636 food-insecure Zambians between May 2004 and March 2005. They observed that 70% of the patients in the food group achieved a medication possession ratio of 95% or greater versus 79 of 166 (48%) among controls (relative risk = 1.5; 95% CI: 1.2 to 1.8) [100]. In another Zambian based study Tirivayi et al, observed that nutritional supplementation promoted adherence to HIV medications. The improvement in adherence rates was greater for participants particularly in the first 230 days (7.5 months) after ART initiation, and among those with initial BMI<18.5 kg/m^2, a higher HIV disease stage, or a CD4+ lymphocyte count ≤ 350 cells/µl [101].

However, the effectiveness of various macronutrient interventions has been questioned by some researchers, because of the limited Randomized Control Trials (RCTs) done to assess the impact of food supplementation on the nutritional status and clinical outcomes of HIV infected adults. One of the critiques was made by Grobler and his colleagues who conducted a Cochrane review in 2009 to evaluate the effectiveness of various macronutrient interventions (given orally), in reducing morbidity and mortality in adults and children living with HIV infection. Based on fourteen small trials they had in their review, they found limited evidence that balanced macronutrient formulas increase protein intake, but there was no evidence that such supplementation translated into reductions in disease progression or HIV-related complications, such as opportunistic infections or death [91]. Similar observations have been made by Koethe and Heimburger in another review conducted in 2009 about the nutritional aspects of HIV-associated wasting in sub-Saharan Africa [102].

2.5 Dietary intake and practices among HIV positive adults

Although there several theories about the cause of weight loss, it is considered that the decrease in energy intake is one of the primary causes of weight loss among people infected with HIV

[103]. This reduction in energy intake could be due to several factors which have been described by Macallan et al. These include: inability of the HIV infected person to get enough foods (in terms of quality and quantity), having poor appetite due to release of various chemicals in the body by the HIV disease (interleukin-1, interleukin-6 and tumour necrosis factor α), and persons infected with HIV having opportunistic infections within the mouth and Gastro Intestinal Tract (GIT) that make it painful or difficult to ingest and absorb the foods eaten [104-106].

In their study conducted in Uganda, Rawat et al, assessed the association between dietary diversity and CD4 count, moderate anaemia and mortality among 876 antiretroviral therapy-naive PLHIV. Using Individual Dietary Diversity Score (IDDS) they followed up the participants for an average of 21.6 months and found the mean IDDS score was 6.3 (SD± 1.7) food groups per day, with a mean of 2.7 (SD± 1.1) nutrient-rich food groups per day. Each additional nutrient-rich food group consumed was associated with a 16% reduction in the likelihood of having a CD4 count ≤ 350 cells/μL (adjusted odds ratio, 0.84; 95% CI: 0.72 to 0.92) at baseline. IDDS was inversely associated with mortality (adjusted hazard ratio, 0.76; 96% CI: 0.63 to 0.91) [107]. Similarly, Koethe and colleagues showed the linkage between low dietary intake and poor nutritional status among HIV positive adults. They found a relationship between patient's appetite, dietary intake, and treatment outcomes after ART initiation. They observed that a 500 kJ/d higher energy intake at any time after ART initiation was associated with an approximate 16% reduction in the hazard of death (Adjusted Hazard Ratio (AHR) = 0.84; (P<0.01), but the relative contribution of carbohydrate, protein or fat to total energy was not a significant predictor of outcome. They also noticed that there was poor outcome among patients with advanced HIV disease and malnutrition, with mortality being predicted by a lower dietary intake [108].

2.5.1 Dietary practices among HIV infected adults

Dietary inadequacies have been observed among PLHIV in resource poor settings both in developed and developing countries [109-111]. Bukusuba et al, conducted a study in 2009 in the Eastern part of Uganda where they investigated the nutritional knowledge, attitudes, and practices of 133 women living with HIV. They found that despite nearly all (99.5%) women living with HIV who participated in the study knowing that it was important to consume a balanced diet, there were only 21% of them (study participants) who consumed at least 3 meals per day and 39.5% who at least ate food consisting of the six main food-groups. The research participants also reported a higher dependency on starchy foods while foods of animal origin and fruits that play a vital immunity and protective roles were inadequately consumed. Unfortunately, in this study the number of research participants investigated was small, the causes of the poor nutritional habits were not investigated and the nutritional status of the research participants was not investigated [112].

In another study, Onyango et al, assessed the nutrient intake and nutrient status of 497 HIV infected patients attending the Chilaimbo clinic in Kenya. They used the 24-hour recall, Food Frequency Questionnaires (FFQ) and nutrient status using biochemical assessment indicators: haemoglobin, creatine, serum glutamate pyruvate transaminase (SGPT) and mean corpuscular volume (MCV). They found out that there was inadequate nutrient intake among the patients, except for iron (10.49±3.49 mg). There were only 55.3% of the respondents that ate three meals a day [113].

Poor dietary practices have been observed among HIV infected adults in other countries other than those in SSA. In one study conducted in India at Chandigarh, a tertiary care centre, dietary intake was assessed by 24 hour dietary recall among 100 HIV infected adults. It was observed both among the male and female HIV-infected individuals that the total energy intake, carbohydrate and protein intake were all significantly lower than the recommended average (for

the females, it was 1564 kcal compared to 1875 kcal, 225 g compared to 230 g and 43.7 g compared to 50 g respectively, while that for the males was 1783kcal compared to 2,425 kcal, 258 g compared with 330 and 51.0 g compared to 60 g) respectively [114].

In Brazil, in a study conducted among 57 HIV infected adults, diet quality was measured using the Healthy Eating Index (HEI). The researchers observed that 64.3% of the participants had a diet needing improvement, while 8.7% had a poor diet. These measurements were based on the HEI scores [115].

2.5.2 Methods of assessing food and dietary intake

According to the FAO, information about food consumption and dietary intake can be collected at the national level (for assessing food supply and production), household level (for assessing food purchases), and at the individual level (for assessing what is consumed). Data collected at the individual level is useful for assessing dietary adequacy and adherence to any set up food based dietary guidelines. There are five different methods for assessing individual dietary intake as described by Thompson and Subar in their book 'Dietary Assessment Methodology'. The methods described in this book include: 24-hour dietary recalls, food records, food frequency questionnaires, diet histories and food habit questionnaires. A combination of different types of dietary assessment methods may be used to improve accuracy and facilitate interpretation of the dietary data [116,117].

2.6 The linkage between food insecurity, malnutrition and HIV/AIDS

Malnutrition is considered to be a direct effect of food insecurity [87]. According to the Food and Agricultural Organisation's 'State of Food Insecurity in the World 2012 Report', an estimated 850 million out of 870 million people who are undernourished are living in developing countries, with nearly 27% of these from sub-Saharan Africa [118]. It is thought that Africa is

the only region in the developing world where food production per person has been declining in the past 40 years [119].

2.6.1 Prevalence of food insecurity among People Living with HIV

Several studies have shown that food insecurity is prevalent among PLHIV. In a study conducted in Ethiopia by Tiyou et al, they determined the prevalence and correlates of food insecurity among 319 HIV infected adults receiving ART at Jimma University clinic. They used the Household Food Insecurity Access Scale (HFIAS) questionnaire and did a multivariable logistic regression model comparing independent risk factors by food insecurity status of the 319 PLHIV. They found out that 201 (63.0%) of the participants were food insecure. Lower food diversity (OR = 2.18; 95% CI; 1.21-3.99), and lower educational status (OR= 3.10; 95% CI: 1.68-5.71) and monthly income <100 USD (OR = 13.1; 95% CI: 4.29 – 40.00) were significantly and independently associated with food insecurity [120].

Comparably similar high prevalence of food insecurity has been observed in developed countries among poor PLHIV. Anema et al, followed up 254 HIV-positive Injection Drug Users (IDU) in British Columbia, in Canada to examine the potential relationship between food insecurity and all-cause mortality. They found out that 181 (71.3%) were food insecure and 108 (42.5%) were hungry. After 13.3 years of median follow-up, 105 (41.3%) participants died. In multivariate analyses, food insecurity remained significantly associated with mortality (AHR = 1.95, 95% CI: 1.07 – 3.53) after adjusting for potential confounders [121].

2.6.2 Effects of food insecurity on the health status of HIV infected adults

Food insecurity is considered to be an important contributor to HIV associated wasting both in resource poor and resource rich settings [122]. In their review on HIV/AIDS, under-nutrition and food insecurity, Ivers et al, noted that food intake by food-insecure people provides them with

limited energy that is below the minimum requirement. This leads to energy and nutritional deficiencies, infections, diseases and loss of productivity [123].

There are different research projects that have been conducted in Uganda demonstrating the different effects of food insecurity on the health of HIV infected adults. One study conducted by Kadiyala et al, observed that HIV positive adults living in food insecure households had low BMI and MUAC. This study was carried out in two districts in Uganda between August 2008 and September 2009 used the HFIAS and IDDS tools. Multivariate regression results demonstrated that HFIAS and IDDS independently predicted BMI (P<0.01) and MUAC (P<0.05). The adjusted odds ratio of being underweight (BMI <18.5kg/m^2) among individuals living in severely food-insecure households was 1.92 (P<0.001); individuals consuming a highly diverse diet had an Adjusted Odds Ratio (AOR) of being underweight of 0.56 (P<0.05) compared with those consuming a diet of low diversity. When they conducted a path analysis, they observed that the indirect effect of food insecurity on BMI mediated through dietary diversity was negligible, and was mostly a result of the direct effect of food insecurity on BMI [123].

Furthermore, food insecurity among PLHIV has been associated with morbidity and poor patterns of healthcare utilization according to the results of the study conducted by Weiser et al while in another study in San Francisco the same author found that food insecurity was associated with increased health services utilisation (hospitalisations, emergency visits) among this study group [124,125]. In another study conducted by Palermo et al, they investigated the association between household food access and individual dietary diversity with Health-Related Quality of Life (HRQL) among people living with HIV in Uganda. They found out that among the 902 PLHIV, those from severe food insecure households had Mean Mental Health Status Score (MMHSS) that were 1.7 points lower (P<0.001) and Physical Health Status Score (PHSS)

that are 1.5 points lower (P<0.01). Individuals with high dietary diversity had MMHSS that were 3.6 points higher (*P*<0.001) and PHSS that were 2.8 points higher (*P*<0.05) [126].

Health workers have received anecdotal information from HIV positive persons that, "it is not just a matter of HIV drugs" but "we also need food to enable us take the medications well". This information is frequently obtained from patients taking antiretroviral drugs who are not having enough food to eat. They report that ARVs give them increased appetite, or make them very weak and unable to carry on their routine activities unless they eat well. This makes it difficult for them to take the drugs if they have no food [30]. Inability to get enough amounts of food and of acceptable quality and consumption pattern of less than three meals a day were significantly associated with non-adherence to ART as was observed by Berhe and his colleagues [127]. Similarly, food insecurity has been associated with poor virological response. This was observed by Wang et al, when they followed up 2,353 HIV infected adults living in the US who were receiving antiretroviral medications for the period 2002 – 2008. There were 24% of the research participants that were described as having food insecurity. In adjusted analyses, food insecurity participants were more likely to have unsuppressed HIV-1 Ribonucleic acid (RNA) (AOR 1.37, 95% CI 1.09 – 1.73) compared to food secure participants [128].

2.6.3 Household food insecurity among the Uganda population

In Uganda, food security is reported to change from one season to another, mainly being influenced by the weather patterns. This was noted by Bahiigwa based on the study he conducted in July 1997 to June 1998 in 14 districts in Uganda. He also observed that despite the seasonal variations in food security, at least 40% of households in Uganda tended not to have enough food to feed themselves at any one point during the period studied [129]. Furthermore, according to World Food Programme (WFP) 2009 Country Report, 72.4% of households in Uganda were thought to be food secure, while the FAO 2011 Uganda Country specific Report indicated that

the declining expenditure share for food – from 68% in 1990 to 44% in 2002 showed an improvement in food access within the country [130].

According to the FAO 2012 Status of Food Security Report, calorie supply per capita for Uganda was estimated at 2,260 kcal with an estimated undernourished population of 22.0%. But it was also reported that the typical Ugandan diet lacks diversity and is not sufficient in providing micronutrients [131]. Similar observations were made in the Comprehensive Food Security and Vulnerability Analysis (CFSV) 2013 report. It was indicated that, nationally, over a third of Ugandans had low dietary diversity (they consumed food from fewer than five out of seven groups in a week leading to the survey) rising to well over half (55%) in the western region [132].

2.6.4 Malnutrition, food insecurity and dietary diversity among refugees in Uganda

Based on information from UNCHR Uganda Country office, nutrition, health and food security assessments are routinely carried out in all refugee settlements in the country. The 2010 food security and nutrition assessment report indicated Global Acute Malnutrition (GAM) of 2.1% in settlements in South West (Kyaka and Nakivale) of Uganda and a prevalence of stunting of 35.8% among children. Households that were deemed to have "acceptable food consumption" were 45.3% which was better compared to an average of 38% for all the other refugee settlements in the country [133].

A survey conducted in 2011, indicated a stunting prevalence in Kyaka and Nakivale refugee settlements among children aged 06 – 59 months of 25.3% (95% CI; 15.8 – 38.0) and 33.9% (95% CI; 28.7 – 39.4) respectively, while severe stunting was 6.4% (95% CI; 2.8 – 14.1) and 9.2% (95% CI: 7.2 – 11.7) respectively [134]. Dietary diversity in the two refugee settlements

was reported as being ‘poor’. The 2011 report showed that, Kyaka and Nakivale refugee settlements had dietary diversity scores of 2 and 3 respectively [135].

2.6.5 Methods of assessing food insecurity

Food insecurity, defined as having uncertain or limited availability of nutritionally adequate or safe food or the inability to acquire personally acceptable foods in socially acceptable ways [68]. Food security entails; food availability, accessibility and utilisation. According to FAO, food insecurity is a complex phenomenon caused by a range of factors and encompasses many elements making it difficult to measure with a single indicator [69].

Because food insecurity is due to many factors, there are several methods for assessing food insecurity based on the intended objective. One such method for assessing food insecurity is the qualitative method of assessing the perceptions of hunger and behavioural responses which is described by Hadaad et al. Information is obtained through inquiring about specific conditions, experiences, and behaviours that serve as indicators of varying degrees of severity of food insecurity by the person interviewed [136]. Another method suggested and used by FAO is through estimating dietary intake and its relation to energy needs thus providing an indication of the availability of food supply [137].

Other methods include using individual dietary and household income and expenditure surveys which measure access to food supplies. The use of anthropometry determines the physical effects of malnutrition on growth and thinness thus indicating the extent of the biological utilization of food [138,139]. Another method mainly used by World Food Programme (WFP) for analysing food security among different populations is the Comprehensive Food Security and Vulnerable Assessment (CFSVA). This method is used to find food insecure and vulnerable households,

identifying the root causes of hunger while analysing the risks and emerging vulnerabilities among populations [140].

2.7 Bioelectrical Impedance Analysis (BIA) as an alternative for assessing body composition

2.7.1 The use of BIA for body composition assessment

Although widely used, Body Mass Index (BMI) has been shown to be an imprecise measurement of fat-free and fat mass, and provides no information if weight changes occur as a result of a decrease in fat-free mass or an increase in fat mass as might be seen among malnourished HIV infected adults or those with other chronic diseases [141]. There are also other limitations of using BMI as was described by Prentice Am and Jebb SA in their viewpoint called "Beyond body mass index". They indicated some of the limitations as: BMI not being capable of showing age-related increases in body fat, racial differences in the relationship between BMI and body fat, the mismatch between BMI and body fat in sportsmen and the effect of exercise on body composition of weight loss during dieting [142]. The inability of BMI to give indication of body composition, muscle mass or nutritional status mean that malnutrition requiring intervention can exist in-spite of a normal to high BMI hence the need to have other ways of measuring body composition to improve the nutritional and clinical management of patients especially those with chronic diseases like HIV and AIDS..

2.7.2 Principles of Bioelectrical impedance Analysis technique

Bioelectrical Impedance Analysis (BIA) is one of the methods used for measuring body composition. Its simplicity, portability, low cost and patient acceptance makes it a desirable technique which is now widely used by clinicians, especially in the resource rich countries to assess body composition of both healthy subjects and patients [143].

In their review, Kyle et al, described the principles of bioelectrical impedance and provided details on its use in measuring body composition. He indicated that any organism is capable of conducting electrical current, and when a constant, low level, alternating current is applied, conduction of that current to the different parts of the body is resisted. Bio impedance is based on the principle that the body acts as a circuit with a given resistance (opposition of current flow through intracellular and extracellular solutions [R]) and reactance (the capacitance of cells to store energy [Xc]) [38].

It is stated that the degree of resistance (R) is related to the composition (make-up) of the organism and the frequency of the applied current. Reactance (Xc) is related to the capacitance properties of the cell membrane, and variations can occur depending on its integrity, function, and composition [38]. Based on these descriptions, fat free tissues which contain large amount of water and electrolytes will present a low impedance electrical pathway, while cell membranes that have fat tissues will act as capacitors and have high impedance [30,144]. The resistance (R) and reactance Xc values are used to calculate impedance (Z) and the phase angle (φ) and these are used to estimate Total Body Water (TBW) in addition to the quantity of Extra Cellular Water (ECW) and Intra Cellular Water (ICW). Fat Free Mass (FFM) can then be calculated, assuming that TBW is a constant part of FFM. On this basis, other body compartments such as Fat Mass (FM) and Body Cell Mass (BCM) can also be measured [144,].

2.7.3 Predictive equations and limitations of using bioelectrical impedance analysis for estimation of body composition

One of the noted drawbacks of BIA is that it predicts TBW rather than measuring it directly, and the relationship between bio-electrical impedance parameters and TBW is known to vary significantly between populations [145]. There have been many empirical equations which have been developed for the estimation of TBW, FFM and BCM, by using sex, age, weight, height and race as explanatory variables. Predictive equations are generally population-specific and

only useful for those populations with similar characteristics to those of the reference populations [146,147]. When these equations have been used to predict body composition in different populations, the results have been inconsistent. The developed predictive equations cannot be generalized to diverse populations. Heyward and Wagner reviewed the reliability and validity of different equations for African Americans, Asians and Indian Americans. They found that the majority of studies indicated that the BIA method is not accurate when a generalized equation is applied for different ethnic groups [148]

2.7.4 Use of direct bio-electrical impedance data

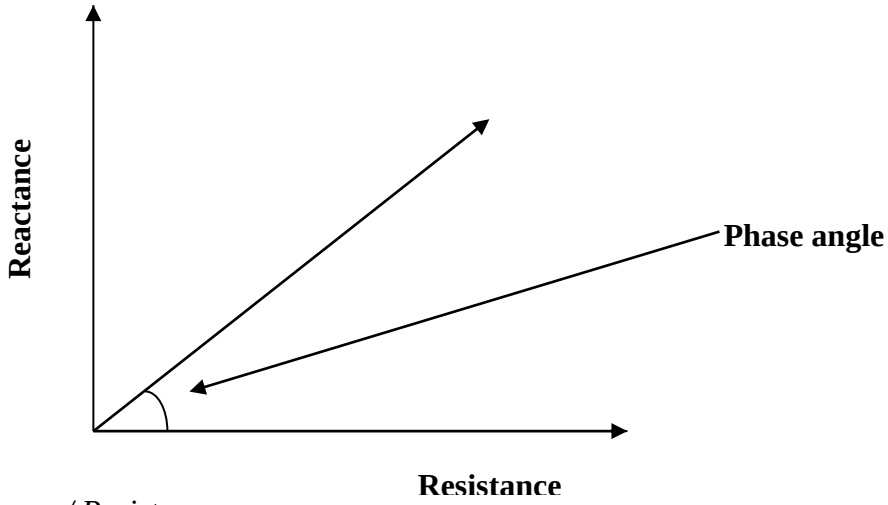
As has been noted above, one of the difficulties of using BIA is that there is need to have predictive equations from the reference population to compare with the group being studied [148,149]. However, in many developing countries these predictive equations are yet to be done and not available. Getting these population specific equations requires resources - time and money – which could sometimes not readily be sourced or available.

The use of direct bio-impedance data has been suggested by different authors and this is based on the electrical measurements used and the different properties of the cell membranes which are said to vary depending on the hydration status, its integrity and composition which changes depending on the health status of the individual [150]. Direct bioelectrical impedance analysis data like: phase angle, resistance and reactance normalized for height in R/Xc graphs are used in assessing the clinical and nutritional status of individuals in relation to their body fat and lean mass [151]. In his paper on simplified approaches to analysis BIA, Wells further suggests the use of the indices like 1/Z (one/impedance), Height^2/Impedance as being useful in ranking in both sexes the Lean Mass Index (LMI) and Fat Mass Index (FMI) [152].

2.7.5 Phase angle

Phase angle is a derived measure obtained from the relation between the direct measures of resistance and reactance as illustrated in Figure 2.3 below [38]. It has been said that PA expresses both the amount and quality of soft tissue and hence an indicator of cellular health, where higher values reflect higher cellularity, cell membrane integrity and better function [153]. In healthy subjects PA usually ranges between 5 and 7^{o} with higher values seen among athletes [153].

Figure 2.3 Diagrammatic presentation of phase angle in relation to reactance (Xc) and resistance (R)



Tan Θ = Reactance / Resistance

Phase angle has been interpreted as an indicator of membrane integrity and water distribution between the intra- and extracellular spaces [154]. Phase angle has also been used to predict body cell mass and for this reason, it has also been used as a nutritional indicator in adults and children [153,154]. Phase angle has been found to be higher among men and athletes compared to women and none athletes. Furthermore, higher BMI has been associated with a higher phase angle while on the other hand poor health been associated with lower phase angle, and identified on its own as having prognostic ability, with phase angle used as a prognosis marker of clinical progression and survival in several disease conditions including HIV infected patients [155,156].

In one study, Schwenk A, Burger B, et al, assessed the prognostic ability of phase angle in 469 HIV-infected patients that were receiving HAART treatment in a clinic in Germany. They found out that a higher PA was associated with a lower relative mortality risk (adjusted for viral load and CD4+ cell count) of 0.49 (95% CI: 0.30, 0.81) per degree in 1996 and of 0.33 (95% CI: 0.18, 0.61) in 1997. The influence of PA on time to clinical progression, adjusted for viral load and CD4+ cell count, was not significant in 1996 but the relative risk was 0.58 (0.36, 0.83) in 1997 [157]. Similar observations were made by Norman et al in the study where the prognostic value of PA was evaluated among cancer patients with respect to nutritional and functional status, quality of life, and six month mortality. Patients with a PA less than the fifth reference percentile had significantly lower nutritional and functional status, impaired quality of life (P<0.0001), and increased mortality (P<0.001). The standardized PA emerged as a significant predictor for malnutrition and impaired functional status in generalized linear model regression analyses. It was also a stronger indicator of 6-month survival than were malnutrition and disease severity in the Cox regression model (P<0.0001) and according to the receiver operating characteristic curve [153].

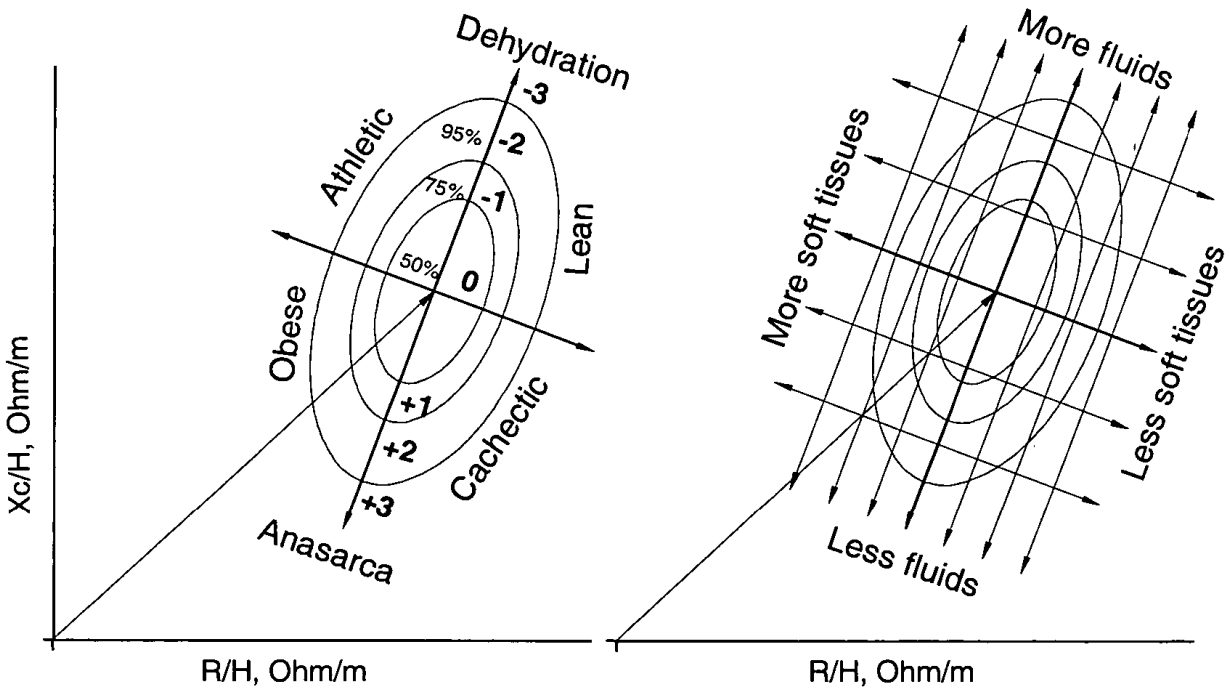
2.7.6 Resistance / reactance graphs and how they are generated

2.7.6.1 Technique of generating the bioelectrical impedance vector analysis graphs

Bioelectrical Impedance Vector Analysis (BIVA) is an integrated part of BIA measurement which is a simple, quick and clinically valuable method for assessing fluid status and Body Cell Mass (BCM). The BIVA method is a novel approach which was developed by Piccoli and his colleagues [39,40]. The hydration status of individuals is estimated by plotting height indexed Resistance (R/H) and Reactance (Xc/R) data got from BIA measurements to plot vectorial bi-variable graph [39]. These vectorial points create the R/Xc graph with tolerance ellipses corresponding to the 50th, 75th, and 95th percentiles as illustrated in **Figure 2.4** below.

In this analysis, displacements of vectors parallel to the higher axis of tolerance ellipses indicate progressive changes in tissue hydration while long vectors above the upper pole indicate dehydration; and short vectors, below the lower pole, indicate hyper- hydration with apparent edema. Vectors descending or migrating parallel to the minor axis indicate the amount of cell mass: above displacements (to the left) indicate higher amount of cell mass; below displacements (to the right), indicate smaller amount of cell mass [39]

Figure 2.4 Reactance and Resistance adjusted for height graphs



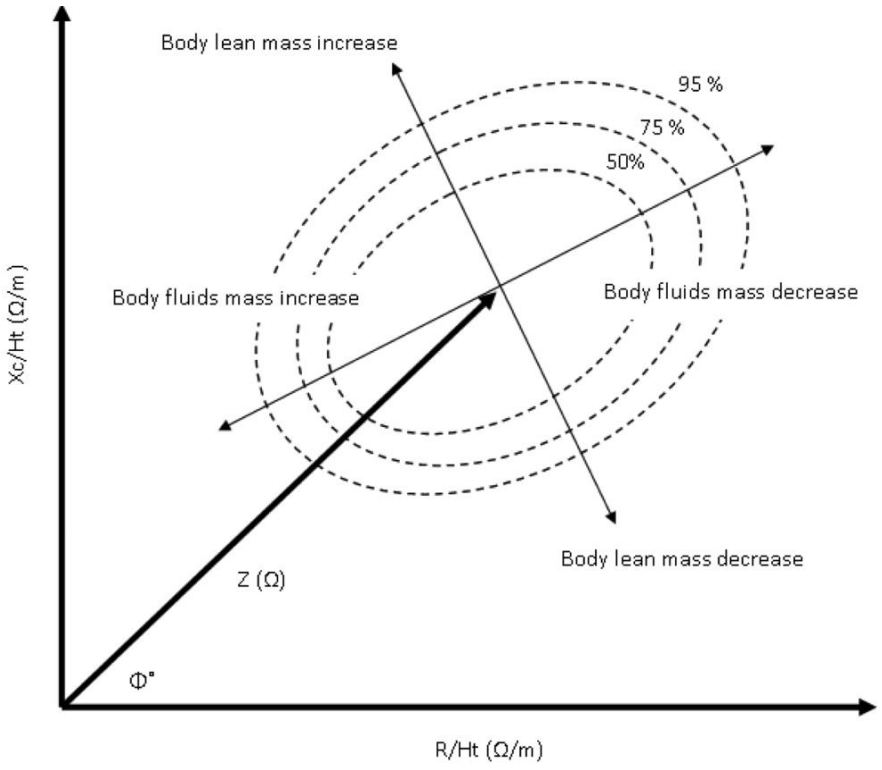
2.7.6.2 Interpretations of the Bioelectrical Impedance Vector Analysis graphs

As described by Piccoli et al, the BIVA approach uses the plot of the impedance parameters Resistance (R) and Reactance (Xc) normalized per height as a bivariate vector in a R/Xc graph [39]. Piccoli urges that the normalization of height allows for the length of the body (conductor) and thus provides a qualitative measure of soft tissue quality that does not depend on body size. The position and length of the vector provides information about the hydration status, body cell

mass and cell integrity. It has been suggested that, in addition to the phase angle, BIVA provides a more detailed understanding of hydration status and cell mass [39].

BIVA is based on patterns of the resistance-reactance graph (RXc graph) relating body impedance to body hydration without equations. Changes in tissue hydration status detected and ranked. Impedance is represented with a point in the ReXc plane which is a combination of resistance, R, which is the opposition to the flow of an injected alternating current, at any current frequency, through intra- and extracellular ionic solutions, and reactance, Xc, which is the dielectric or capacitive component of cell membranes and organelles, and tissue interfaces. Clinical information on hydration is obtained through patterns of vector distribution with respect to the healthy population of the same race, sex, class of body mass index.

Figure 2.5 Resistance / Reactance normalized by height graph indicating tissue changes at different levels of tolerance ellipses



2.7.7 Impedance (Z) related indices (1/ Impedance and Height^2/Impedance)

In their review of the principles of BIA, Kyle and colleagues indicate that impedance value (Z) generated by BIA reflects the resistance and reactance that the electrical signal encounters when passing through the body; the ionized fluid in the lean tissue act as conductor, and the current passes only through these fluids [38]. There have been studies done which demonstrated that physical measurements of impedance can produce useful estimates when appropriately transformed [44]. Wells proposed the use of 1/Z (one /impedance) as a simple height-adjusted lean index after showing that LM/Height^2= (Height^2/Z)/Height^2 = 1/Z [154].

2.8 Conclusion from the literature review written above

The reductions in the number of new HIV infections and deaths from AIDS due to the availability of improved prevention, treatment, care and support services has been globally acknowledged [14,51]. However, despite all these achievement, it has been rightly suggested that there is still a great deal that needs to be done especially in resource poor countries and settings where many people continue to delay in getting to know their HIV sero-status and hence are unable to seek appropriate and timely treatment and care [52].

Delay in knowing one's HIV sero-status leads to late presentations with many first-timers to the clinic being diagnosed with HIV wasting syndrome (3rd or 4th WHO HIV/AIDS clinical stage), and many other HIV co-morbidities [19]. With the widespread under-nutrition and food insecurity especially in SSA, newly identified PLHIV or those already accessing HIV care services are malnourished or at risk of getting malnourished before and after starting on antiretroviral treatment [19,54]. Because of the effects of nutrition on the improvement and well-being of PLHIV, research on different ways of improving the assessment and monitoring of the

nutritional status of PLHIV is crucial. Health care providers need to have appropriate tools for determining and monitoring the nutritional status of PLHIV, and also know the factors which may affect the nutritional wellbeing of PLHIV.

In Uganda, BMI and MUAC are the commonly used methods for assessing, screening and monitoring the nutritional status PLHIV [90]. Unfortunately these do not adequately determine the lean muscle mass of an individual yet it is the changes in the metabolically active lean muscle mass of HIV-infected adults which is important in predicting the morbidity, mortality and functionality of PLHIV [142]. This makes it necessary and important to investigate the possibility of using bioelectrical impedance data and its applicability, especially in resource poor settings.

Like many other infectious diseases, the interaction of nutrition and HIV has a great effect on the wellbeing of the people living with HIV [61]. Opportunistic infections and the HIV infection itself put a high energy demand on those infected with the disease, and yet many of them have inadequate food intake and of limited dietary diversity [69]. This might result in their inability to meet their nutritional demands which may affect their adherence to prescribed HIV medication [71]. There is a need to investigate the dietary practices and food security status of refugees and those staying within the settlement where access to food might be inadequate. This will provide a basis for the health care providers to give appropriate nutritional counselling and support for adults infected by HIV and other chronic infectious disease.

Chapter 3. Methods

3.1 Introduction

This chapter consists of seven key broad sections.

In section 3.2, I describe the study settings for both the cross sectional and longitudinal study providing some general background information about refugees who are formally living in Uganda and officially registered by UNHCR. In the same section, I also include information about Kyegegwa Health Centre IV where I conducted the longitudinal study.

In section 3.3, I describe the two components - cross sectional and longitudinal studies – which constituted this research study. In sections 3.4 and 3.5, I give an overview of the study designs for the cross sectional and longitudinal study respectively. This includes information about sample size estimation, sampling and selection procedures for the research participants for the two studies.

The focus of section 3.5 of this chapter is the data collection processes in which I highlight the different equipment used for data collection, the data collection tools (questionnaires), the interview and measurement procedures.

In section 3.6, I provide information on how data was managed including the quality control and data analysis processes. In the last section of this chapter (section 3.7), I provide information about the ethical considerations, consent and approvals I got to conduct the two studies.

3.2 Study settings

There were two study sites for the cross sectional study; Kyaka and Nakivale refugee settlements while the longitudinal study was conducted from Kyegegwa Health Centre IV. All the three study sites are found in the western and south-western part of Uganda.

3.2.1 Refugees in Uganda

Uganda has hosted nationals from other countries since the time of the Second World War when some European nationals settled in different camps within the country [158]. Over the years, nationals from the neighbouring countries like: Rwanda, Burundi, Democratic Republic of the Congo (DRC), Sudan (and South Sudan), Eritrea, Somalia and Kenya have been hosted in Uganda at different times. Similarly, Ugandan nationals have been refugees too; in the 1970s and 1980s during the time of expulsion of Asians, and then later during the different conflicts and wars that followed in the two decades when many Ugandans fled to neighbouring countries and beyond [159].

According to UNHCR, Uganda's location within the Great Lakes region of Africa coupled with the political volatility of the region, places it at the centre of one of the largest refugee-generating areas in the world [160]. As of August 2012, Uganda was host to over 190,000 refugees and asylum seekers mainly from: DRC, Somalia, Burundi, Rwanda, and South Sudan where conflicts, wars and violence have forced them to leave their countries [20].

3.2.2 Settlements of refugees

Refugees in Uganda live in settlements resembling villages as opposed to camps. The settlements are found in different parts of the country. The refugees move freely within the settlements and surrounding villages and there is social interaction between refugees and Ugandan nationals (host populations). The GoU allocates refugees land to settle and grow their foodstuffs (to promote 'self-reliance' and livelihood) based on the number of people within a given family (household). The nature of settlements, and the act of refugees being provided land are not common practices and liberties accorded to refugees living in many countries in Africa; these practices made Uganda to be described by UNHCR as being a "very generous" host country [161]. Generally, refugees receive health and other social services like: education, water and sanitation, food supply from UNHCR, WFP and their different implementing partners. In

some instances refugees can also access healthcare services from government owned health facilities.

Figure 3.1 Refugee sites in Uganda[7]

[7] Courtesy of UNHCR: http://www.unhcr.org/pages/49e483c06.html

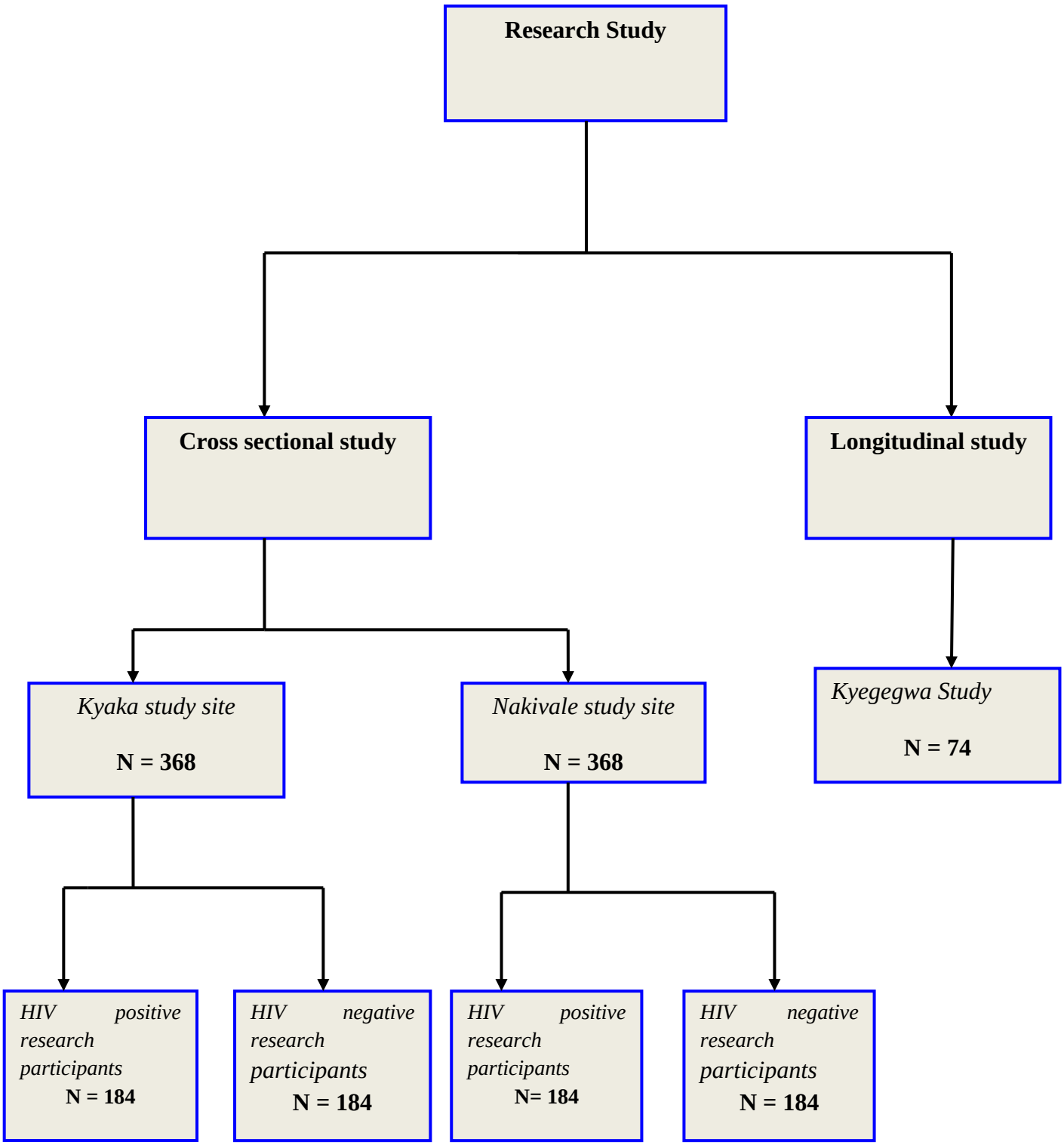
Figure 3.2 Locally made RUTF which has been named 'RUTAFA'[8]

3.3 Study components

There were two major studies that are referred to in this thesis as study components. The first study was a cross sectional descriptive study involving known HIV positive and 'confirmed[9]' HIV negative research participants living in Kyaka and Nakivale refugee settlements, and the second study was a longitudinal observational study conducted in Kyegegwa Health Centre which involved malnourished HIV positive research participants. The Figure 3.3 below summarizes the two studies that I conducted and the corresponding participants.

[8] RUTAFA, a native name celebrating life. RUTAFA is a quality RUTF made from locally sourced ingredients including peanuts, sugar, soy oil, palm oil, milk and essential minerals and vitamins.
[9] 'Confirmed' HIV negative participants refers to those adults who were tested for HIV and found to be HIV negative (HIV negative sero-status).

Figure 3.3 Flow diagram showing the studies conducted



3.4 Study design for the cross sectional study

For the cross sectional study, I used a descriptive observational study design to assess and describe the prevalence of malnutrition and ascertain the association of nutritional status with household food security access, individual dietary practices, Hand Grip Strength (HGS), and description bioelectrical impedance analysis parameters. The variables collected were compared for HIV positive and HIV negative research participants.

3.4.1 Selection of research participants for the cross sectional study

3.4.1.1 Selection of HIV positive adults for the cross sectional study

A. Target Population

These were HIV positive adults – refugees and Ugandan nationals - attending the HIV clinics in Kyaka and Nakivale health centres found within the two refugee settlements. The HIV positive adults were identified from the patients' register available at the HIV clinics of the respective health facilities – in Kyaka and Nakivale health centres.

B. Inclusion and exclusion criteria for enrolment into the cross sectional studies

Only HIV positive adults (those aged 18 years and above at the time of the study), and whose names were written in the patients' register in each of the two health centres (Kyaka and Nakivale) at the time of the start of the study, were eligible for enrolment into the cross sectional study. The age of the research participants was confirmed from the patients' register. In the sampling list, I excluded: HIV positive patients that had died but whose names had not been removed from the main patients' register, HIV positive women whose names were also found in the PMTCT register[10], women who were either pregnant or breastfeeding at the time of the study or during the assessment or interview period (women research participants were always asked

[10] At the time of the study, women enrolled into the HIV clinic who became pregnant were then referred to the PMTCT clinic for further management.

about their Last Normal Menstrual Period (LNMP), to ascertain those that might be pregnant), patients who had not attended the HIV clinic for the past four consecutive months[11], and HIV positive adults who at the time of the survey were being admitted onto the in-patient wards of the two health facilities.

C. Sampling Frame / Sampling List

I created a sampling list from the main adult HIV positive patients' register based on patients that were attending the HIV clinics at the time of the study. I took into consideration of the study inclusion and exclusion criteria. Afterwards, I created a separate sampling list for female and male HIV positive patients. At the time of the study, there were approximately 1.6 times more females compared to male HIV positive patients that were registered in the HIV clinics of Kyaka and Nakivale health facilities. The final number of research participants that were selected to be part of the study was proportionally constituted of females and males HIV positive patients within the respective HIV study clinic.

D. **Sampling frame / list for HIV positive adults for Kyaka study**

The sampling list I used for selecting HIV positive adults from Kyaka Health facility / settlement consisted of *898* HIV positive adults (*351* male and *547* female adult patients) who were eligible to participate in the cross sectional study.

E. Sampling frame / list for HIV positive adults for Nakivale study

[11] As part of the HIV treatment procedures and guidelines, HIV patients are required to come back to the HIV clinic for review at least once every month. However based on the clinician's assessment, some HIV patients who stay very far away from the clinic and are fairly well would be given medications to last them two months.

The final sampling list that I used for enrolment of HIV positive adult research participants from Nakivale Health facility / settlement consisted of *691* HIV positive adults of whom *263* were males and *428* females who were eligible for inclusion in the cross sectional study.

3.4.1.2 Selection of HIV negative adults for the cross sectional study

A. Target Population

This consisted of 'confirmed' HIV negative adults living within the refugee settlements and its neighbouring villages where the Ugandan nationals live. The 'confirmed' HIV negative adults acted as 'neighbourhood-controls' to the HIV positive adults living within the same communities. The HIV negative adults were selected from those people living within the demarcated zones (based on where the HIV positive research participants resided), and had been tested for HIV either from the health facility or mobile VCT services, and found to be HIV negative during the period of the study.

B. Inclusion and exclusion criteria for HIV negative adults into the study

For any research participants to be included in the study, they had to be 'confirmed' HIV negative adults. Their HIV sero-status had to be first confirmed through the testing done by the HIV Counselling and Testing (HCT) teams. These teams conducted HIV testing sessions within the refugee settlements and the adjacent villages during the time of the study. Enrolment into the study would then be conducted after getting the HIV test results.

Like the HIV positive research participants, HIV negative research participants had to be aged 18 years and above at the time of the interview. Only residents of the two settlements or villages neighbouring the settlements were eligible to participate in the study. Pregnant women, breast feeding mothers and adults with chronic diseases like TB, diabetes, etc were excluded from participating in the cross sectional study.

C. Sampling Frame / Sampling List

My sampling frame / list consisted of those adults who had tested HIV negative. This was done separately for male and female research participants. I used a similar gender ratio (1 male : 1.6 females) as had been used when selecting the HIV positive research participants for the study. Thereafter, we used the demarcated zones (areas of residence for HIV positive research participants) when selecting for HIV negative adults so as to have a comparable number of refugees and nationals, and males and female study participants within the two study sites.

3.4.2 Sample size estimation and sampling procedures for cross sectional studies

3.4.2.1 Sample size estimation for HIV positive and HIV negative research participants

The primary outcomes for the cross sectional study were; the means and proportions of malnutrition, levels of household food insecurity access based on the HFIAS scores and Individual dietary diversity scores (IDDS). The sample size was calculated using single population proportion formula with confidence level of 95% and 5% significance level. Based on the cross sectional study design, I used the formulae for calculating sample size for population less than 10,000 as described by Hulley et al [162].

$$n=2z^2pq/d^2$$

n = the desired sample size;

z = standard normal deviation which was set at 1.96 corresponding to 95% confidence interval;
p = we assumed that there were at least 40% of HIV infected adults who are malnourished
q= 1-p – we thought that an observed difference of 10% between those who are HIV infected and those that are HIV negative will be significant at 95% confidence interval. After substituting in the above figures, I then calculated the sample size as follows;

$$n= 2(1.96)^2(0.4)\ (0.6) / 0.1^2$$

$$\boldsymbol{= 184}$$

A. Sample size for HIV positive adult research participants

I had a total sample size of 736 research participants for the cross sectional study. This consisted of **368** HIV positive adults from the two HIV clinics 368 HIV negative adults all from Kyaka and Nakivale settlements.

During the time of conducting the research study, there were more females than males, approximately at a ratio of 1:6, who had been enrolled into the respective HIV care clinics of Kyaka and Nakivale settlements. Based on the ratios used, there were 460 females compared to 276 males who constituted the research participants of the cross sectional study.

This gender difference in utilisation of HIV/AIDS services has been noted in other HIV clinics in the developing countries and is not only common to the two HIV clinics for the study (Kyaka and Nakivale health facilities). More women have been noted to be accessing HIV and AIDS services compared to men one case being results from Muula's systematic review on gender distribution of adult patients on HAART in SSA [163].

3.4.2.2 Sampling procedure for HIV positive adults for cross sectional study

A. Kyaka refugee settlement

Female HIV positive adult research participants for cross sectional study

After considering the inclusion and exclusion criteria, there were **547** female HIV positive adult patients on the sampling list for Kyaka HC III eligible to participate in the study. I assigned numbers to the **547** HIV positive adults from **1** up to **547**. Since I needed to select **115** females (based on the sample size and the ratio of number of females to male HIV positive adults attending the HIV clinic), I calculated a sampling interval of **4**. I then used a random table to randomly select the starting number. Thereafter, the study participants were selected by simple random sampling for every **4th** person in the sampling list until the required sample size was achieved.

In the research log book *'Number 1'*, I recorded identification particulars of the selected female study participants. I included the following information; name of the person selected and her place of residence, age, and the expected date of her next visit to the clinic. I shared this information with the clinicians at the health facility. When the selected research participant came for review to the health facility, she was then informed about the study. The research assistants provided further information to the selected research participant once she had agreed to participate in the study. If the selected study participant did not turn up for review for two consecutive months, she was then replaced with another eligible HIV positive female adult.

Male HIV positive adult research participants for cross sectional study

The sampling list for male HIV positive adults for Kyaka HC III had **351** people. There were **69** male HIV study participants that had to be selected from the sampling list of **351** eligible HIV positive male adults.

I assigned numbers from **1** up to **351** for all the eligible male HIV positive patients. Based on the number of study participants to be sampled and the number of eligible HIV infected male adults, I calculated a sampling interval of **5**. Afterwards, I used a random table to get the starting number corresponding to the patient that was to be selected first. Using simple random sampling method, I then selected every **5^{th}** number of the corresponding patient for recruitment into the study.

I used the research log book *'Number 2'* to record the information about the selected male study participants. This information included; the name, residence, age and expected date for the next review for the HIV positive patient selected to participate in the study. I shared this information with the clinicians so that if they (clinicians) reviewed any of the selected HIV infected persons, he was then referred to the research assistant.

B. Nakivale refugee settlement

Female HIV positive adult research participants for cross sectional study

After considering the inclusion and exclusion criteria, there were **429** HIV infected patients on the sampling list of Nakivale HC III that were eligible to participate in the study. I then assigned the **429** HIV infected adults numbers from **1** up to **429**. Since we needed **115** females as per the sample size and the ratio of females to male HIV positive adults attending the HIV clinic, I calculated a sampling interval of **4**. I then used a random table to randomly select the starting number. Thereafter, the study participants were selected by simple random sampling for every **4th** person in the sampling list until the required sample size was achieved.

In the research log book *'Number 3'*, I recorded identification particulars of the selected female study participants. I followed the same procedures in Nakivale as I had done in Kyaka refugee settlement.

Male HIV positive adult research participants for cross sectional study

Based on the sample size and the female to male ratio used, I had to select **69** male HIV positive study participants from the sampling list of **263** eligible HIV positive male adults. I then assigned numbers 1 up to **263** for all the eligible male HIV positive patients. Based on the number of study participants to be sampled and the number of eligible HIV infected male adults, I calculated a sampling interval of **4**. Afterwards, I used a random table to get the starting number corresponding to the patient that was to be selected first. Using simple random sampling method, I then selected every **4th** number of the corresponding patient for recruitment into the study.

I used the research log book *'Number 4'* to record the information about the selected male study participants. I followed the same procedures to select the male research participants as I had done for Kyaka refugee settlement.

3.4.2.3 Enrolment of the selected HIV positive adults into the cross sectional study

I was assisted by two research assistants to enrol the research participants when they came for their routine reviews at the respective ART clinics. The ART clinics run once every week. Data collection was conducted first in Kyaka refugee settlement and later in Nakivale health centre. I used the information in the respective study sites and the study log books I set up to identify and track the HIV positive adults that were to be enrolled into the study.

To ensure that all the selected individuals were enrolled into the study, we requested other patients that knew those people to inform them to turn up to the clinic on their respective dates of review. If the person who had been selected to participate in the study failed to turn up for eight consecutive weeks, that individual was dropped and then replaced by someone else.

3.4.2.4 Sampling procedure for HIV negative adult research participants

A. Kyaka refugee settlement

I identified the different areas (zones) of the settlement and its neighbouring villages based on the information gathered from the respective camp commandants. I compared this information with the different sites to be visited by the mobile VCT team for Kyaka health facility for their outreach HIV testing activities. Based on the information provided, I divided the settlement into eight zones with two of them being the villages for nationals. These zones corresponded to the different areas which HIV positive research participants indicated as their areas of residence. We therefore selected at least 25 HIV negative adults from the eight different zones among the people that had been tested for HIV and found to be HIV negative.

B. Nakivale refugee settlement

I divided the settlement into six zones based on the areas that were to be visited by the mobile VCT team and similar to where most of the HIV positive research participants resided. In Nakivale health facility, based on the health facility registers, nearly 90% of HIV service users

are refugees. Because of this reason, I did not consider categorising the people (refugees or nationals) tested for HIV as most of them would be refugees as there were only a few nationals using HIV services provided in Nakivale HC III. We aimed to recruit at least 30 HIV negative participants from each of the six zones that we set up for the study.

3.4.2.5 Enrolment of HIV negative research participants

After receiving their HIV test results and post testing counselling, I had a meeting and discussion with those individuals that had had a negative HIV test. I provided information about the study, those who can participate and reasons for their involvement. The HIV negative people who wanted to participate were then provided with information, clarifications and answers to the questions they had. Afterwards, those that agreed to participate in the study were requested to provide both verbal and written consent to the research assistants. I then enrolled them into the study, and thereafter the interviews and assessments were conducted.

3.5 Study design for longitudinal study

I conducted a longitudinal observational study to investigate the changes in nutritional status, household food security access, individual dietary diversity / practices, body composition parameters as measured by bioelectrical impedance analysis, and functionality of malnourished HIV positive adults who were receiving nutritional supplementation as part of their routine care and management.

The repeated measures were compared over the 16 weeks of stay in the study and investigation done to know if there was a relationship between the observed nutritional changes with some of the selected BIA parameters.

3.5.1 Target population for longitudinal study

I targeted malnourished HIV positive adults admitted into the nutrition clinic of Kyegegwa health centre. Staff at this nutrition clinic regularly screen HIV positive adults attending the ART clinic within the health centre to ascertain their nutrition status. Those newly identified malnourished HIV positive adults were the ones eligible to be recruited into the longitudinal study.

A. Inclusion and exclusion criteria for the longitudinal study

First, to be eligible for enrolment into the longitudinal study, one had to be HIV positive and aged 18 years and above. Secondly, the eligible person was either moderately or severely malnourished based on the Uganda's Ministry of Health admission criterion which was being used for the nutrition programme in Kyegegwa HC IV. Female research participants were required to be neither pregnant nor breastfeeding at the time of inclusion into the study. Malnourished HIV positive adults who required admission on to the wards for in-patient management were also excluded from taking part in the study[12].

B. Follow up of research participants in the longitudinal study

Once recruited into the study, research participants were followed-up for up to sixteen weeks after inclusion into the study. Follow-up was undertaken during the time they visited the nutrition and HIV clinic. In principle, all malnourished HIV positive patients are supposed to be reviewed at least once every four weeks. During this time, they receive their medications and food supplementation to last them the next four weeks. But, there are instances when some of the malnourished HIV patients do not turn up on the indicated dates of visits (dates of review). There are some of the patients who default (not turning-up for at least two subsequent months after the

[12] Study participants who happened to get admitted for in-patient care during the time of the study (follow-up) continued to be part of the study.

last visit) and ‘lost to follow-up’ is possible as has been noted in some other health facilities [164].

I was assisted by the research assistants to conduct the reviews and follow-ups of the study participants when they came back for their respective clinic days. We conducted reviews between three to six weeks. Study participants who failed to come back for the scheduled follow-up sessions for two consecutive months (eight weeks) were considered as defaulters and therefore removed from the study.

3.5.2 Sample size estimation for longitudinal study

For the longitudinal study, I carried out repeated measurements for the malnourished HIV positive adults who were recruited into the study.

The primary outcomes for this study were; (a) changes in nutritional status as measured by weight, MUAC and BMI, (b) changes in BIA parameters - phase angle, reactance, resistance, impedance and reactance and resistance normalised by height, (c) changes in household food insecurity and (d) changes in HGS.

I was interested in testing the difference between the mean weights, anthropometric and other variables measured on admission into the nutrition programme and after 16 weeks of nutritional rehabilitation of the research participants.

I used the formula below for calculating the sample size where the sample size estimate depends on the difference between the means and the within-group variability of individual measurements as described by Andrienko et al [165].

$$n = 16s2 / d2 + 1$$

n = the required sample size; d = the expected mean difference in weight worth detecting (variability) which was estimated at 14 gm/day

s = the standard deviation which was taken as 30,

After substituting in the different figures, I calculated the sample size as below;

n= (16) (30)2 / 142 + 1

= 73.09

I therefore considered **74** participants for the longitudinal survey

3.5.3 Recruitment of the study participants for the longitudinal study

The staff working in the nutrition clinic routinely took anthropometric measurements (weight, height and MUAC) of all patients attending the HIV care clinic. Once a new HIV positive patient was identified as being malnourished based on either BMI or MUAC, he/she was then referred to our 'study room' which we had set up for possible enrolment into the study based on the eligibility criteria. I provided the necessary information about the study and checked if the referred individual met the study inclusion criteria. Thereafter, I took the verbal and written consent from the identified individuals for their participation in the study, and subsequently enrolled then into the study and did the different assessments and interviews.

3.6 Data collection process

I was assisted by three research assistants during the whole process of data collection. The recruited research assistants were health workers with experience in data collection. Further description of the training and supervision the research assistants received is described in the section of data management, quality control and analysis.

In the sub-sections below, I describe the key information and data that was collected, and the different data collection tools (questionnaires) that were used, and the preparations carried out as part of the quality control process.

3.6.1 Anthropometric assessment

We collected the following anthropometric measurements;

A. Weight

Research assistants weighed the research participants using a digital weighing scale of *SECA type, model 761*. Before the beginning of the day activities, one of the research participants calibrated the weighing scale using a standardized 10 Kg weight[13]. The research participant was requested to remove his/her shoes or sandals, heavy clothes like jackets, and asked to empty his/her pockets. He/she stood in the centre of the platform to ensure that the weight is evenly distributed. After 30 seconds, the research assistant recorded the weight measurement to the nearest 0.1kg.

B. Standing height

We used the *stretch stature* method for measuring height as described by Tanner [166]. We measured the maximum distance from the floor to the vertex of the head and recorded the standing height of the study participant. Research assistants took the height of the research participants using a SECA 213 portable stadiometer with a measuring rod. The height board was positioned on a hard-flat and even surface.

The research participant was instructed to remove his/her shoes, stand up straight against the backboard with the body weight evenly distributed, both feet held flat on the standing plane (platform) and arms hanging at the side. The head was held in the Frankfort plane with the top of the external auditory meatus (canal) level with the inferior margin of the inferior margin of the lowest point of the eye socket [167]. The height was then recorded to the nearest 0.1cm.

C. Mid Upper Arm Circumference

One of the research assistants requested the research participant to stand upright with the shoulders relaxed, and remove the clothes to expose the right arm. The research participant stood on the right side of the participant and identified with a mark the middle point of the arm (between the acromion process of the scapular and the olecranon process). The measuring tape

[13] The weighing scale was positioned on a hard-flat surface and adjustments done so that the pointer was at zero before any weighing measurement was done.

(MUAC tape) was wrapped around the arm at the mid-point mark perpendicular to the long axis of the upper am. The tape was made to be just fitting and not compressing the skin. The measurement was taken to the nearest 0.1cm.

3.6.2 Household Food Security Assessment

We conducted assessment of the access component of household food security for all the research participants.

3.6.2.1 Assessment tool – Household Food Insecurity Access Scale

I used the Household Food Insecurity Access Scale (HFIAS) tool which was developed by Food and Nutrition Technical Assistance (FANTA) and has been validated in several countries [168]. The HFIAS tool is a standardized questionnaire consisting of nine questions which measure different aspects of food access insecurity. The tool is based on the thinking that an individual's experiences of food insecurity (access) can cause predictable reactions and responses. The nine occurrence questions relate to three different domains of food insecurity (access) [169]. The nine occurrence questions are described below;

A. *Anxiety and uncertainty about the household food supply:*

ii. Did you worry that your household would not have enough food?

B. *Insufficient Quality (includes variety and preferences of the type of food):*

iii. Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?

iv. Did you or any household member have to eat a limited variety of foods due to a lack of resources?

v. Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?

C. Insufficient food intake and its physical consequences:

vi. Did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?

vii. Did you or any household member have to eat fewer meals in a day because there was not enough food?

viii. Was there ever no food to eat of any kind in your household because of a lack of resources to get food?

ix. Did you or any household member go to sleep at night hungry because there was not enough food?

x. Did you or any household member go a whole day without eating anything because there was not enough food?

3.6.2.2 Interview procedure

One of the research assistants interviewed the research participants using the adapted HFIAS questionnaire. The research participants responded to the questions / statements read out to them with the answers provided recorded accordingly. The interview about the household food security usually lasted about 45 minutes.

3.6.3 Assessment of dietary diversity and food intake

I used the FAO approved Individual Dietary Diversity (IDD) tool to assess the different foods consumed by the research participants over the past 24 hours prior to the interview [168]. I adapted the IDDS questionnaire which consisted of 14 different food groups (categories) based on the majority of the foods eaten by the communities involved in the two studies.

The different categories / groups of foods included in the questionnaire were; cereals, vitamin A rich vegetables and tubers; white roots and tubers; dark green leafy vegetables; other vegetables;

vitamin A rich fruits; other fruits; organ meat; flesh meat; eggs; fish; legumes, nuts and seeds; milk and milk products; oil and fats.

The recall period of 24 hours was used as it is less subject to recall error, less cumbersome for the respondent and conforms to the recall time period in many other dietary diversity studies [170]. A potential disadvantage of using 24-hour dietary recall is the inability to remember all foods eaten especially among the elderly and sick. The research assistants used probing techniques to ensure that research participants were able to recall most of the foods that they ate the previous 24 hours.

3.6.3.1 Interview procedure

Before the interview, the research assistants gave a brief explanation to the research participants of what information was required. Thereafter they requested the research participants to mention first the number of meals (breakfast, lunch, supper and any special meals) he/she had eaten the previous day from the time they woke up. Once the number of meals had been established, inquiry was then made about the actual drinks and foods that were eaten during the mornings (breakfast), lunch time and then supper time. This information was recorded by the research assistant on to the IDDS questionnaire corresponding to the different food groups and categories. Afterwards, the research participants were asked about the possible foods, fruits or drinks eaten in between the meals. This information was then recorded by the research assistant in the corresponding food groups on the IDDS questionnaire.

3.6.4 Hand Grip Strength measurements

Hand Grip Strength (HGS) is an index measurement of the power of the hand and general upper body strength [171]. We used the Jamar dynamometer to measure the HGS of the research participants. The Jamar dynamometer measures in Kilogram force (Kg) the force produced by an isometric contraction.

Before the HGS was measured, we explained to the research participants how the hand dynamometer works, and gave a demonstration to show how the participant will hold it. The research participant had to stand upright while pressing the dynamometer to the maximum ability using his/her 'dominant' hand. Two consecutive measurements were taken five minutes apart. The mean value was then calculated and recorded.

3.6.5 Body composition assessment using Bioelectrical Impedance Analysis

I used a Bodystat® QuadScan 4000 Multi-Frequency Bioelectrical Impedance Analyser (MFBIA) for assessing the body composition of the research participants. This was the last assessment that was carried and was done when the research participants had rested for between three to four hours after arrival at the HIV and nutrition clinic.

3.6.5.1 Procedure followed for conducting Bioelectrical Impedance Analysis

I adapted the guidelines from Bodystat® (Bodystat® Body Composition Test) the manufacturers of the BIA equipment I used. The process of collecting bioelectrical impedance data involved the following[14]:

- Before the assessment was conducted, I showed the research participant the BIA machine, and provided him/her some basic information on how it works and how the assessment was to be carried out. I then gave opportunity to the research participant to ask any questions which were answered accordingly.
- The research participants was asked to remain in light clothing, and told to remove any metallic items like mobile phones, keys, belts, shoes, watches, or rings that they might have had in their pockets. When ready for assessment, the research participant was requested to lie on a table specifically prepared for conducting body composition assessments. One of the

[14] http://www.bodystat.com/QSeries/Product3-Details/QuadScan-4000.aspx

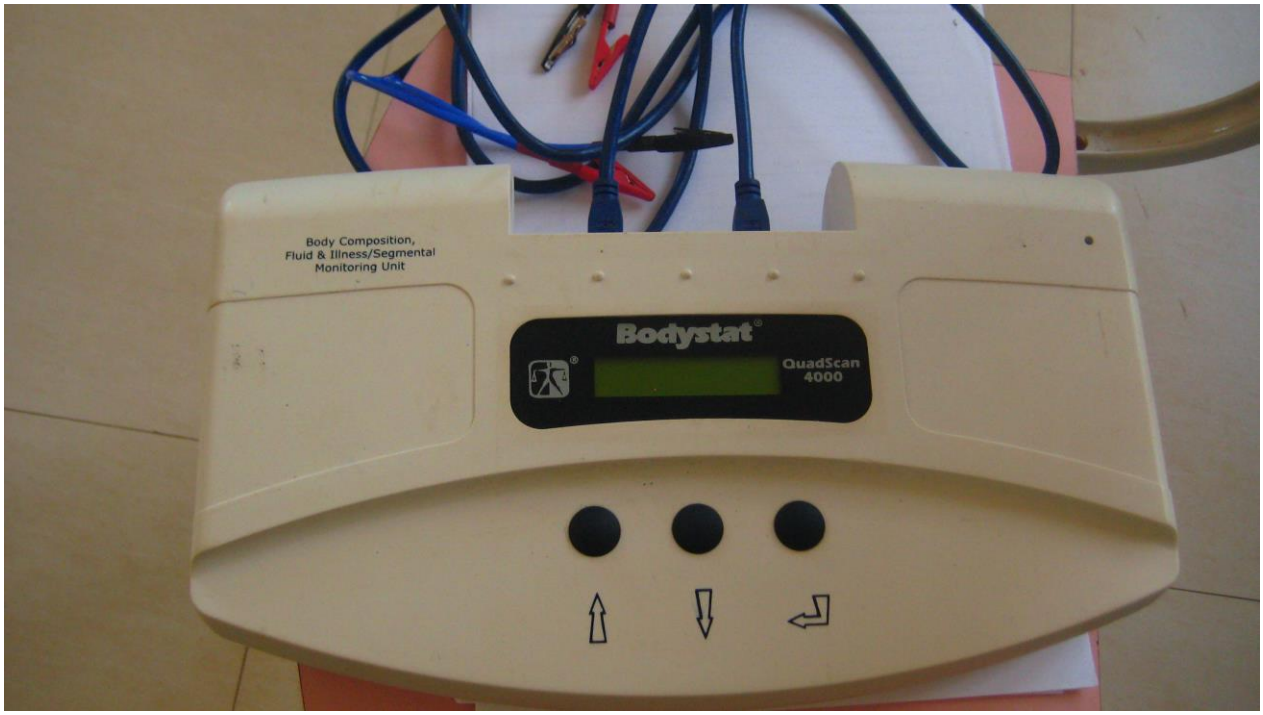
research assistants ensured that the research participant to be assessed lay in supine position with no parts of his or her body touching one another.

- I cleaned the right hand (area behind the knuckle of the middle finger and that on the wrist next to the ulna head) and foot (areas behind the 2nd toe next to the big toe and on the ankle at the level of and between the medial and lateral malleoli) where the electrodes were then placed. I always put the electrodes on the right foot and hand of the research participants.
- The crocodile clips were then attached to the metal tab strip of the electrodes and the QuadScan 4000 unit was then switched on. The data for weight, height, gender, waist and hip circumference were then keyed in. After 3 to 4 minutes of the research participant lying in the supine position, the Enter key was then pressed for the machine to perform the measurement.
- After displaying the results on the screen, the crocodile clips and the electrodes were removed from the research participant. The research assistant asked the research participant to sit-up and then referred them for any further instructions. The results of the measurement were then recorded on the questionnaire reading from the QuadScan 4000 unit screen.

3.7 Data management, quality control and data analysis

I developed a Standard Operating Procedure (SOP) that we used as a guideline and reference for the data collection and management process. The SOP was used when selecting research participants, conducting the assessments and interviews and handling of the questionnaires after data collection had been carried out. For data analysis, I developed a data analysis plan that I used to guide me during the data analysis process.

Figure 3.4 Bioelectrical impedance analyzer machine used for assessing bioelectrical impedance for research participants



3.7.1 Quality control processes

I had three research assistants who assisted me during the process of data collection. My assistants were health workers with previous experience in conducting interviews, nutritional assessments and data collection. Two of the research assistants are trained enrolled nurses while the third one is a trained clinical officer.

Below are the different procedures and activities I set up to ensure that data collected was of high quality and with minimal errors.

3.7.1.1 Training of research assistants

First, we had an orientation training for two days focusing on taking anthropometric measurements, ensuring accuracy and consistence, facilitated by a nutritionist from Makerere University School of Public Health.

Secondly, I conducted another five-day training course for the three research assistants with the objective of equipping them with the necessary knowledge and skills in conducting the

assessments and interviews, and taking the different measurements. The training covered the following topics; (a) revision and general overview about nutrition and anthropometric measurements, (b) appropriate ways of taking anthropometric measurements (weight, height, MUAC, waist, hip and thigh circumference), (c) general procedures for preparing research participants for bioelectrical impedance analysis, (d) how to conduct had grip strength, and (e) appropriate interviewing techniques.

We had three days of practical sessions conducted at Kyegegwa HC IV. The first day we practiced on the correct techniques and procedures of taking the anthropometric, and hand grip strength measurements based on the guidelines that I had compiled. On the second day, each of the two research assistants independently took anthropometric, and hand grip strength assessment for 5 people admitted in the health facility in the morning and then later in the afternoon.

I observed and critiqued the techniques of the measurements and then later assessed inter and intra observer variations in the measurements. There were very minimal differences in the anthropometric measurements. I was responsible for conducting bioelectrical impedance analysis for all the research participants.

3.7.1.2 Pretesting of data collection tools

We pre-tested all the questionnaires before collecting the research data. This was done on the third day of the practical session as part of the training. Apart from finding out how people responded to the different questions, the pre-testing exercise enabled the research assistants to become even more familiar with the questions and also strengthen their skills in conducting the assessments and interviews.

After the pre-testing of the questions, we agreed on how to ask about the food eaten during the previous 24 hours before the interview as well as the questions about access to food in the last four weeks before the interview.

3.7.1.3 Supervision and monitoring performance of the research assistants

During the days for data collection, two research assistants worked with me to carry out the assessments and interviews. The research assistants mainly focused on taking the anthropometric and HGS measurements plus conducting the interviews using the HFIAS and IDD tools. I regularly monitored the performance of the research assistants, and any identified problems were discussed appropriately to ensure that assessments and interviews were conducted correctly.

3.7.2 Equipment calibrations

A. Weighing scale

During the whole process of data collection, I used one weighing scale that had been loaned to me from Kyegegwa HC IV. Each day before starting any weight measurements, the weighing scale was placed on a hard, flat and even ground. Thereafter, the research assistant adjusted the weighing scale's reading pointer to the zero mark. A 5kg weighing stone which I had borrowed from a coffee purchasing businessman was then put on the weighing scale to check if the weighing scale measurement corresponded with the weight of the 5kg stone. The research assistant then did the necessary adjustment on the scale.

B. Stadiometer

Before any height measurement was conducted, the stadiometer was placed on a hard and even surface with the height rod well fixed and well fitted.

C. Bodystat Quadscan (Multi frequency bioelectrical impedance analyser)

The calibration was done based on the equipment user's guide provided by the manufacturer. A calibrator was used for the calibration of the machine after conducting 100 measurements as was

recommended by the manufacturer. I followed all the necessary precautions and procedures as described in the user's manual of the BIA machine.

D. Variability of Bioelectrical impedance analysis measurements

BIA predicts Total Body Water (TBW) which has been reported to vary depending on the hydration status of an individual [38,39]. I measured the BIA parameters of five people (three males and two females) at three different times of the day (early morning (between 8.30a.m – 10.00am), early afternoon (between 12.30p.m – 2.30p.m) and evening (between 5.30p.m – 7.30p.m). The results got showed that there were minimal variations in the data got for the three measurements that were taken among the five volunteers at different times of the day. Interviews were conducted at least two hours after the participants had reached the health facility during which time the selected participants were requested not to take any fluids as a way of ensuring minimal changes in their hydration status.

3.7.3 Data cleaning and entry

Before the end of each day of data collection, I reviewed all the filled in questionnaires to check for completeness and accuracy of the information that was provided. We corrected any errors observed and where we were not certain, the respective questionnaire was noted in the log book for the corresponding study.

After all the reviewed done, I assigned a number for each of the completed questionnaires. The number on the questionnaire corresponded to the one that was in the study log book. The filled in questionnaires were tied and put in a box for further transportation to Kampala.

3.7.4 Data entry

I used EpiData Version 3.1 for data entry [172]. By developing the EpiData check files, I was able to use the error detection features of EpiData. This ensured that during data entry, errors that would have otherwise occurred when wrong numbers are inadvertently entered were greatly minimised.

For the cross-sectional study, I separately handled the data entry for the questionnaires for HIV positive and HIV negative research participants. The data set files for HIV positive and HIV negative research participants were merged afterwards.

To further minimise errors during the data entry process, two EpiData files (separately for either HIV positive or HIV negative research participants) were developed in which data was entered, one by me and another by a contracted data entrant. After all the data had been entered, I compared the two data files to check for any inconsistencies between the two files. When any inconsistencies were found I compared the information entered with that provided in the respective questionnaires (hard-copies).

After the reviews and when appropriate changes had been made, I had one 'corrected' version of the Epidata files for the HIV positive and HIV negative research participants. Hence, there were two 'corrected' data files for the cross sectional study which were later merged into one file for analysis.

For the longitudinal study, there were four corrected data files made – each one corresponding to each of the four interview (assessment) sessions that were conducted. The four files were then merged into one data set.

3.7.5 Data analysis

A. Exporting EpiData files into SPSS statistical programme

I used EpiData Version 3.1 for data entry as described in section 3.6.4 above. After the data cleaning process, I got the final dataset for the cross sectional and longitudinal study.

While working on the results of each study component, I exported the respective file to Excel version 2007, and thereafter to IBM SPSS Statistics Version 19 programme [173]. After this process, I created the SPSS dataset file for each study component. The IBM SPSS Statistics Version 19 statistical programme was then used for the subsequent statistics analysis.

B. Further data cleaning and checking for outliers

For each SPSS dataset, I first conducted an 'eye balling' process of the dataset. This was to check any obvious missing data and outliers (data which was seen to be beyond the average). For any discrepancies noticed, I cross checked with the corresponding information on the data entry sheet (Epi Data files) and also with the questionnaire (hard copies).

I also performed exploratory checks which included conducting frequencies, normality tests, and scatter plots. This was also to further check for missing data and outliers. The necessary corrections were made as was required.

3.7.5.1 Data analysis

I conducted the data analysis in three main phases for each of the respective study components.

In the first phase of the analysis, I conducted descriptive statistical analysis mainly for single variables (univariable data analysis). I summarized the data based on the key variables of the study in relation to the different research questions which I presented mainly as frequencies and percentages.

Secondly, I conducted bivariable data analysis to find out the associations and correlations between two identified key variables and did Chi square and student t-tests were done providing the p-values as the tests of significance (statistical tests).

Thirdly, I conducted multivariable analysis to enable me to answer the research hypotheses which included analysing the Exposure Variables (EV) with the Outcome Variables while adjusting for the different co-variables.

3.7.5.2 Analysis of the bio-electrical impedance data

I was not able to conduct a validation study to measure impedance and TBW and establish equations specific for my study population because of inadequate resources. The known available BIA equations among blacks are for populations from West African and South Africa who also greatly differ in physical stature compared to the populations in East Africa. I used

individual BIA parameters, because of the possible inaccuracies that could occur with using BIA equations not specific to my study population [148].

3.8 Ethical considerations and research participants' consent to participate in the study

3.8.1 Seeking research participants' consent to participate in the study

I briefed all HIV positive adults attending the three HIV clinics where the two studies were carried out. The briefings took place during the visits to the HIV clinics based on the respective appointments. This briefing focused on; (a) providing general information about the study, (b) the kind of people that could participate and those that are to be excluded, (c) the kind of assessments and interviews to be conducted, (d) the reasons for conducting the study, and (d) importance of the studies and the necessity to conduct them including benefits to individuals that were to participate in the study and to the wider community and PLHIV.

We answered questions which the research participants had as well as providing explanations about the study. This was done either at the beginning of the study, during or after the study.

On participation and benefits; the selected research participants were informed that participation was voluntary; there were no individual benefits and anyone could withdraw from the study at any time even if assessments had been started, and that withdrawal from the study could not deny the research participant from receiving any of the services provided at the clinic or anywhere within the settlements of villages.

The selected research participants first gave a verbal approval to participate in the study and thereafter also signed a consent form accepting to be involved in the study before any assessments and interviews were conducted. Those who were unable to write provided a thumb print instead of their signature. The signed consent forms and those with thumb-prints were kept and each stapled together with the questionnaires of the respective research participant.

3.8.2 Ethical approvals for the research study

First, I made a presentation of the research protocol to the Institution Review Board (IRB) of Makerere University College of Health Sciences (MUCHS). This was in-line with the guidelines for requesting for permission to conduct of research in Uganda. After the IRB approval the research protocol was submitted to the Uganda National Research Ethics Committee.

Secondly, I submitted the protocol to Uganda National Council of Science and Technology (UNCST), for review, and approval was then granted. After the in-country approval had been granted, the research protocol was then submitted for approval by University College London (UCL) and this was also granted.

Thirdly, approval was sought and granted from the authorities of Kyegegwa and Isingiro districts where the three study sites are found, and from UNHCR country office and the Refugee Department of the Office of Prime Minister (OPM) in Uganda.

3.8.3 Privacy and confidentiality

We conducted the interviews and assessments in two separate rooms; one room was used for the interviews while the second room was used for taking the different anthropometric measurements and the body composition assessments. During the interviews, only the research participant to be interviewed and the research assistants were present in the room. All other research participants were asked to wait in another adjacent building until they were called upon for their turn.

All questionnaires used were anonymous (no names of the research participants were included). A research number was assigned to each research participant. This research number was used for linking up all the four questionnaires for the different assessments that were conducted. Once all the assessments were completed, the questionnaires for each respective research participant were bound together, sealed in a box and then transported to the principal investigators' home.

Chapter 4. Results for the cross sectional study of HIV positive and HIV negative residents of Kyaka and Nakivale refugee settlements

4.1 Introduction

In this chapter, I present the key results for the cross sectional study conducted in Kyaka and Nakivale refugee settlements. This study had a total of 736 research participants of which 368 were HIV positive and 368 were HIV negative.

I explored three hypotheses during the data analysis process as shown below together with the related research questions that were answered.

Hypothesis 1: HIV infection is a risk factor for food insecurity among adult residents of refugee settlements in south-western Uganda.

The related research questions are:

*1.1 What are the dietary practices of HIV positive and HIV negative adults? This question is explored in **section 4.4.1** of this chapter.*

*1.2 What is the relationship between household food insecurity and the nutritional status of participants? This question is answered in **section 4.4.2** of this chapter.*

*1.3 Does household food insecurity differ depending on the HIV status of the research participants? This question is answered in **section 4.4.3** of this chapter.*

Hypothesis 2: HIV infection is a risk factor for malnutrition among adult residents of refugee settlements in Western Uganda.

The related research questions for this hypothesis are:

*2.1 What is the prevalence of malnutrition based on BMI or MUAC among HIV positive and HIV negative adults? This question is answered in **sections 4.5.1 and 4.5.2** of this chapter.*

*2.2 What is the relationship between nutritional status and functionality (hand-grip strength) in HIV positive and HIV negative research participants? This question is answered in **section 4.5.3** of this chapter.*

Hypothesis 3: HIV infection is associated with changes in bioelectrical impedance parameters among adult residents of refugee settlements in Southwestern Uganda.

The research questions related to this hypothesis are:

*3.1 What are the mean values of bioelectrical impedance parameters for HIV positive and HIV negative adults? This question is answered in section **4.6.1** of this chapter.*

*3.2 What is the relationship between nutritional status and the bioelectrical impedance values of research participants? This question is answered in section **4.6.2** of this chapter.*

4.2 Structure of chapter 4

I present this chapter in five broad sections based on the key results of the cross sectional study and the hypothesis I explored. Section 4.3 has results on the demographic, socio-economic characteristics, and self-reported health status of the research participants.

In section 4.4, I present results about household food security including the dietary diversity of research participants and provides the analysis that tests hypothesis 1. Sections 4.5 and 4.6 have results on anthropometric indices and hand grip strength respectively. The last section of the chapter – section 4.7 – has results that relate to the bioelectrical impedance analysis for the different categories of the participants for cross sectional study.

4.3 Demographic, socio-economic and self-reported health status of research participants

4.3.1 Demographic and socioeconomic characteristics of participants from Kyaka and Nakivale refugee settlements

Between November 1, 2011 and May 2012, I enrolled 736 research participants for the cross sectional study from Kyaka and Nakivale refugee settlements. Below I present the characteristics of the sample in table 4.1 and 4.2, stratified first by refugee settlement and secondly by HIV status.

Each settlement had 50% of the research participants drawn for the study as was described in chapter 3 under section 3.4.1. and further highlighted in **Table 4.1** below. Females constituted nearly 63% of the participants. Furthermore, refugees constituted 71% of the participants with the Congolese nationals being over 55% of the total number of participants for the cross sectional study. Non-refugees (Ugandan nationals) constituted 48% and 9% of the participants from Kyaka and Nakivale study sites respectively. Nearly a third of the participants (32%) had had no formal education.

When participants were considered based on their HIV status, those who were HIV positive were significantly older compared to HIV negative participants. Based on HIV status, refugees constituted 74% and 69% of HIV positive and HIV negative research participants respectively.

Table 4.1Characteristics of cross sectional study participants by study site[1]

Category		Kyaka		Nakivale		Total	
		Frequency or mean	(% or SD)	Frequency or mean	(% or SD)	Frequency or mean	(% or SD)
N		368	(50.0)	368	(50.0)	736	(100.0)
Age in years		35.9	(9.8)	35.5	(11.2)	35.7	(10.6)
Gender	Male	137	(37.2)	136	(37.0)	273	(37.1)
	Female	231	(62.8)	232	(63.0)	463	(62.9)
HIV Status	HIV +ve	184	(50.0)	184	(50.0)	368	(100.0)
	HIV –ve	184	(50.0)	184	(50.0)	368	(100.0)
Refugee status	Refugee	*191*	(51.9)	*334*	(90.8)	525	(71.3)
	Non-refugee	*177*	(48.1)	*34*	(9.2)	211	(28.7)
Nationality	Ugandans	*177*	(48.1)	*34*	(9.2)	211	(28.7)
	Rwandese	52	(14.1)	51	(13.9)	103	(14.0)
	Burundians	6	(1.6)	8	(2.2)	14	(1.9)
	Congolese	133	(36.1)	275	(74.7)	408	(55.4)
Educational status	No FE[15]	137	(37.2)	96	(26.1)	233	(31.7)
	Formal Education[16]	231	(62.8)	272	(73.9)	503	(68.3)
Family size	0 – 4 people	190	(51.6)	207	(56.3)	397	(53.9)
	5 – 8 people	140	(38.0)	95	(25.8)	235	(31.9)
	≥ 9 people	38	(10.3)	66	(17.9)	104	(14.1)

[1]Values in italics differ significantly between the refugee settlements ($p<0.05$)

[15] No FE = No Formal Education

[16] Formal Educations either consisted of primary, secondary or tertiary training.

Table 4.2 Characteristics of cross sectional study participants by HIV status[1]

Category		HIV positive		HIV negatives		Total	
		Frequency or mean	(% or SD)	Frequency or mean	(% or SD)	Frequency or mean	(% or SD)
N		368	(50.0)	368	(50.0)	736	(100.0)
Age in years (SD)		*37.4*	(9.3)	*34.1*	(11.5)	35.7	(10.6)
Gender	Male	136	(37.0)	137	(37.2)	273	(37.1)
	Female	232	(63.0)	231	(62.8)	463	(62.9)
Study Site	Kyaka	184	(50.0)	184	(50.0)	368	(50.0)
	Nakivale	184	(50.0)	184	(50.0)	368	(50.0)
Refugee status	Refugee	*272*	(73.9)	*253*	(68.8)	*525*	(71.3)
	Non-refugee	*96*	(26.1)	*115*	(31.3)	*211*	(28.7)
Nationality	Ugandans	96	(26.1)	115	(31.3)	211	(28.7)
	Rwandese	57	(14.5)	46	(12.5)	103	(14.0)
	Burundians	8	(2.2)	6	(1.6)	14	(1.9)
	Congolese	207	(56.3)	201	(54.6)	408	(55.4)
Educational status	No FE[17]	137	(37.2)	96	(26.1)	233	(31.7)
	Formal Education[18]	231	(62.8)	272	(73.9)	503	(68.3)
Family size	0 – 4 people	190	(51.6)	207	(56.3)	397	(53.9)
	5 – 8 people	140	(38.0)	95	(25.8)	235	(31.9)
	≥ 9 people	38	(10.3)	66	(17.9)	104	(14.1)

[1]Values in italics differ significantly between the HIV +ve and –ve participants ($p<0.05$)

[17] No FE = No Formal Education

[18] Formal Educations either consisted of primary, secondary or tertiary training.

4.3.2 Self-reported health status of research participants

The results in **Table 4.3** below show that, there were twice as many HIV positive research participants compared to HIV negative research participants (30% and 16% respectively) who were not feeling well at the time of the interview. This showed a statistically significant association between HIV sero status and the health status (feeling unwell) of the study research participants ($p<0.05$).

Table 4.3 Self-reported health status of HIV positive and negative participants

HIV status	Reported feeling	Study site				Total	
		Kyaka		Nakivale			
		Frequency	%	Frequency	%	Frequency	%
HIV Positive	Feeling well	136	73.9	123	66.8	259	70.4
	Feeling unwell	48	26.1	61	32.2	109	29.6
HIV negative	Feeling well	150	81.5	161	87.5	311	84.5
	Feeling unwell	34	18.5	23	12.5	57	15.5

Among the HIV positive research participants, 54% of them were taking Anti-Retroviral (ARVs) drugs at the time of the interview.

The results in Table 4.4 below show that approximately half (49%) of the HIV positive Ugandan research participants had been taking ARVs for more than 13 months at the time of the interview. For HIV positive refugees taking ARVs, half of them had been started on ARVs within the past 6 months at the time of the interview. There was a statistically significant

difference between HIV positive refugee and Ugandan nationals taking ARVs within three months of being recruited in the ART programme ($p<0.05$).

Table 4.4 Cross tabulation of months since starting ARV treatment with nationality and location of HIV positive participants

Nationality	Months	Study site				Total	
		Kyaka		Nakivale			
		Frequency	%	Frequency	%	Frequency	%
Ugandan	0 – 6 months	7	18.9	10	62.5	17	32.1
	7 – 12 months	8	21.6	2	12.5	10	18.9
	≥ 13 months	22	59.5	4	25.0	26	49.1
Refugees	0 – 6 months	18	27.3	54	68.4	72	49.7
	7 – 12 months	12	18.2	8	10.1	20	13.8
	≥ 13 months	36	54.5	17	21.5	53	36.6
Combined	0 – 6 months	25	24.3	64	67.4	89	44.9
	7 – 12 months	20	19.4	10	10.5	30	15.2
	≥ 13 months	58	56.3	21	22.1	79	39.9

4.4 Dietary practices and household food security of research participants for the cross sectional study

4.4.1 Individual dietary diversity

In the three tables below (Table 4.5, 4.6 and 4.7), I have highlighted the results of Individual Dietary Diversity Scores (IDDS) for different categories of research participants.

The **Table 4.5 below** show that; overall the IDDS for combined research participants was 3.6. HIV positive research participants had significantly lower IDDS compared to HIV negative research participants: 3.3 and 3.8 respectively ($p<0.05$). Similarly, research participants from Kyaka study site had significantly higher IDDS compared to those from Nakivale study site ($p<0.05$). Likewise based on refugee status of the participants, refugees had significantly lower IDDS compared to Ugandan nationals ($p<0.05$).

Table 4.5 Mean Individual Dietary Diversity Score for different groups of research participants

Category	Mean IDDS	SD	SE	p-value
Combined (N = 736)	3.56	1.55	0.0 57	
HIV positive (n = 368)	3.30	1.53	0.080	0.000
HIV negative (n = 368)	3.85	1.55	0.081	
Kyaka (n = 368)	4.39	1.52	0.079	0.000
Nakivale (n = 368)	2.76	1.12	0.058	
Ugandans (n = 211)	4.23	1.63	0.112	0.000
Refugees (n = 525)	3.31	1.45	0.058	

As shown in Table 4.6 below, more than half (54%) of all research participants were in the 'lowest dietary diversity' category (ate foods in ≤ 3 food groups) in the 24 hours before the interview.

More than two-thirds (61%) of the HIV positive compared to 46% of the HIV negative research participants were in the 'lowest dietary diversity' category. There were twice as many refugees as nationals who were in the 'lowest dietary diversity' category (34% and 62% respectively) with $p<0.05$.

Table 4.6 Dietary diversity categories by HIV and refugee status

HIV status	Dietary Diversity (DD)	Refugee Status				Total	
		Ugandans		Refugees			
		Frequency	%	Frequency	%	Frequency	%
Combined	Lowest DD	72	34.1	323	61.5	395	**53.7**
	Medium DD	93	44.1	161	30.7	254	34.5
	High DD	46	21.7	41	7.8	87	11.8
HIV positive	Lowest DD	44	45.8	181	66.5	225	61.1
	Medium DD	34	35.4	74	27.2	108	29.3
	High DD	18	18.8	17	6.3	35	9.5
HIV negative	Lowest DD	28	24.3	142	56.1	170	46.2
	Medium DD	59	51.3	87	34.4	146	39.7
	High DD	28	24.4	24	9.5	52	14.1

The results in **Table 4.7** below indicate that: there were two and half times more participants from Nakivale refugee settlement who were in the 'lowest dietary diversity' category compared to those from Kyaka refugee settlement; 78% and 29% respectively. Furthermore, there were two times more HIV positive research participants in the 'lowest dietary diversity' category compared to those who were HIV negative; 88% and 34% respectively. There were statistically significant associations between being in the lowest dietary diversity category and both HIV status and place of residence ($p<0.05$).

Table 4.7 Cross tabulation of dietary diversity categories by HIV status and study site

HIV status	Dietary Diversity (DD)	Study site				Total	
		Kyaka		Nakivale			
		Frequency	%	Frequency	%	Frequency	%
Combined	Lowest DD	107	29.1	288	78.3	395	53.7
	Medium DD	180	48.9	74	20.1	254	34.5
	High DD	81	22.0	6	1.6	87	11.8
HIV positive	Lowest DD	63	34.2	162	88.2	225	61.1
	Medium DD	89	48.4	19	10.3	108	29.3
	High DD	32	17.4	3	1.6	35	9.5
HIV negative	Lowest DD	44	23.9	126	68.5	170	46.2
	Medium DD	91	49.5	55	29.9	146	39.7
	High DD	49	26.6	3	1.6	52	14.1

4.4.2 Household Food Insecurity Access Scale (HFIAS) of research participants in the cross sectional study

In the five tables below - Table 4.8, 4.9. 4.10, 4.11 and 4.12 -, I present results on household food security for different categories of research participants.

In **Table 4.8** below, the results show that HIV positive research participants had significantly higher HFIAS score of 5.01 compared to 4.18 for HIV negative research participants ($p<0.05$). Similarly, research participants from Nakivale settlement had a significantly higher mean HFIAS score compared to those of Kyaka refugee settlement. Furthermore, refugee research participants had significantly higher mean HFIAS score compared to Ugandan research participants ($p<0.05$).

Table 4.8 Mean HFIAS Score for different groups of participants[19]

Category	Mean HFIAS Score	SD	SE	p-value
Combined (N = 736)	4.60	4.27	0.157	
HIV positive (n = 368)	5.01	4.81	0.251	0.008
HIV negative (n = 368)	4.18	3.60	0.188	
Kyaka (n = 368)	3.29	4.67	0.244	0.000
Nakivale (n = 368)	5.91	3.34	0.174	
Ugandans (n = 211)	3.75	4.47	0.308	0.001
Refugees (n = 525)	4.94	4.13	0.180	

[19] The HFIAS score is a continuous measure of the degree of food insecurity (access) in the household in the past four weeks (30 days). The maximum score for a household is 27 and a minimum score of 0 (food secure). The higher the score, the more food insecurity (access) the household experienced.

In **Table 4.9**, the results indicate that overall, less than half of the research participants (43%) were categorized as being from 'food secure' households based on the Household Food Insecurity Access Prevalence (HFIAP). Based on nationality, 53% and 39% of the Ugandan and Refugee research participants respectively were classified as 'food secure'. The number of HIV positive and HIV negative research participants who were food secure was similar; 44% and 42% respectively.

Table 4.9 Categories of food security levels by HIV and refugee status[20]

HIV status	Food security status	Refugee status				Total	
		Ugandan		Refugees			
		Frequency	%	Frequency	%	Frequency	%
Combined	Food secure	112	53.1	203	38.7	315	42.8
	Mildly food insecure	82	38.9	257	49.0	339	48.1
	Mod. food insecure	10	4.7	59	11.2	69	9.4
	Severely food insecure	7	3.3	6	1.1	13	1.8
HIV negative	Food secure	63	54.8	90	35.6	153	41.6
	Mildly food insecure	47	40.9	137	54.2	184	50.0
	Mod. food insecure	4	3.5	26	10.3	30	8.2
	Severely food insecure	1	0.9	0	0.0	1	0.3
HIV positive	Food secure	49	51.0	113	41.5	162	44.0
	Mildly food insecure	35	36.5	120	44.1	155	42.1
	Mod. food insecure	6	6.3	33	12.1	39	10.6
	Severely food insecure	6	6.6	6	2.2	12	3.3

[20] Four levels of household food insecurity (access): food secure, mildly food insecure, moderately and severely food insecure – depending on the experiences reported during the past 30 days.

The results in **Table 4.10** indicate that, based on their residence, 61% and 24% research participants of Kyaka and Nakivale refugee settlements respectively were classified as being from 'food secure' households. The results indicated a statistically significant association of food security level and the residence of the research participants. There was no evidence that HIV positive and HIV negative research participants had a different food security status ($p>0.05$).

Table 4.10 Cross tabulation of food security levels by HIV status and study site

HIV status	Food security status	Study site				Total	
		Kyaka		Nakivale			
		Frequency	%	Frequency	%	Frequency	%
Combined	Food secure	226	*61.4*	89	*24.2*	315	42.8
	Mildly food insecure	111	30.2	228	62.0	339	46.1
	Mod. food insecure	18	4.9	51	13.9	69	9.4
	Severely food insecure	13	3.5	0	0.0	13	1.8
HIV negative	Food secure	107	58.2	46	25.0	153	41.6
	Mildly food insecure	72	39.1	112	60.9	184	50.0
	Mod. food insecure	4	2.2	26	14.1	30	8.2
	Severely food insecure	1	0.5	0	0.0	1	0.3
HIV positive	Food secure	119	64.7	43	23.4	162	44.0
	Mildly food insecure	39	21.2	116	63.0	155	42.1
	Mod. food insecure	14	7.6	25	13.6	39	10.6
	Severely food insecure	12	6.5	0	0.0	12	3.3

Table4.11 Cross tabulation of household food security categories with selected variables

Variable		Food secure households		Food insecure households		P –value[21]
		Frequency	%	Frequency	%	
Refugee status	Ugandan	112	53.1	99	46.9	*0.000*
	Refugee	203	38.7	322	61.3	
HIV status	HIV positive	162	44.0	206	56.0	*0.503*
	HIV negative	153	41.6	215	58.4	
Study site	Kyaka	226	61.4	142	38.6	*0.000*
	Nakivale	89	24.2	279	75.8	

Nearly two thirds (61%) of refugees were from 'food insecure' households compared to just less than half (47%) of the Ugandan nationals as illustrated in **Table 4.11** above. There was a statistically significant association of the nationality of the research participant and the food security status of their respective household ($p<0.05$). Similarly, more than three quarters (76%) of research participants from Nakivale settlement compared to less than a third (39%) from Kyaka settlements were from 'food insecure' households. The results showed a statistically significant association of the residence (study site) of the research participant and their food status ($p<0.05$).

[21] Based on Chi square

The results in **Table 4.12** below show that, there was no significant association of food security status of the participants' households and their nutritional status, either based on BMI or MUAC ($p>0.05$).

Table 4.12 Cross tabulation of food security status of participants and their nutritional status based on both body mass index and mid upper arm circumference

Variable		Food secure households		Food insecure households		P –value[22]
		Frequency	%	Frequency	%	
BMI	≤ 18.49 kg/m^2	40	42.6	54	57.4	0.915
	≥ 18.50 kg/m^2	274	42.7	421	57.3	
MUAC	≤ 23.99 cm	72	48.0	78	52.0	0.149
	≥ 24.00 cm	243	41.5	343	58.5	

4.4.3 Testing of Hypothesis 1 : HIV infection is a risk factor for food insecurity among adult residents of refugee settlements in Western Uganda.

First, I carried out a *simple linear regression analysis* with HIV infection as the Exposure Variable (EV) and Household Food Insecurity Access Scale (HFIAS) score as the Outcome Variable (OV). HFIAS score is a continuous variable with a range of 27[23].

Secondly, I ran a *multivariable linear regression analysis* using the enter method with HIV infection as the EV and Household food insecurity access scale score as the OV, to explore and

[22] Based on Chi square

[23] The HFIAS score is a continuous measure of the degree of food insecurity (access) in the household in the past four weeks (30 days). The maximum score for a household is 27 and the minimum score is 0.

adjust for the other variables (covariates): age, gender, family size, education status, occupation, health status, site of residence, time after testing HIV positive and nationality.

The results of the two models for the bivariable and multivariable regression analysis are shown in the **Table 4.13** and **Table 4.14** below respectively.

Table 4.13 Linear regression analysis of HIV status and HFIAS score (n= 736)

Model	R^2	F test	β	P value	95% CI
HIV status	0.09	[1,734] 6.99	- 0.097	0.003	-1.444, -0.214
HIV status adjusted*	0.116	[9,726] 10.597	0.070	0.112	-1.335, 0.140

* = *multivariable regression analysis adjusted for age, gender, family size, education status, occupation, health status, site of residence, time after testing HIV positive, and nationality.*

R^2 = R squared; β = beta coefficient; 95% CI = 95% Confidence Interval

The results of the unadjusted, bivariable linear regression indicated that while HIV infection only explained 1% of the variance in food insecurity it was however a significant risk factor for food insecurity in the sampled population.

The results of multivariable regression analysis indicated that the variables in the model explained about 12% of the variance of the outcome variable (HFIAS score) – food insecurity. Furthermore, the results indicated that after adjustment for these variables, HIV infection was not a statistically significant exposure ($p>0.05$). However, the study site variable was significantly related to HFIAS score with $\beta = 6.52$; CI: [2.045, 3.808], $p < 0.05$ as shown in Table 4:14 below. Even after repeated multiple linear regression analyses, where I manually removed one variable and checked the performance of the different models while maintaining the other variables (this was repeated for all the variables), I found that there was no significant change of R^2 within the model summaries and the β coefficients generated. In all these analyses and different models

generated, it was only the β coefficient for the study site variable which remained statistically significant.

Table 4.14 Multivariable regression analysis of HIV status and HFIAS score (n=736)

Covariates[24]	Unstandardized Coefficients		Standardized Coefficients			95% CI for Beta	
	B	SE	Beta	t	Sig	Lower Bound	Upper Bound
Constant	1.144	1.610		0.710	0.478	-2.018	4.305
Age	-0.002	0.015	-0.006	-0.153	0.879	-0.032	0.027
Gender	-0.460	0.310	-0.052	-1.481	0.139	-1.069	0.150
Family Size	0.078	0.052	0.054	1.515	0.130	-0.023	0.180
Occupation	-0.405	0.336	-0.046	-1.205	0.228	-1.064	0.254
Education level	0.566	0.344	0.062	1.645	0.100	-0.109	1.241
Health status	0.181	0.362	0.018	0.499	0.618	-0.530	0.892
Study site	2.926	0.449	0.343	6.516	***0.000***	2.045	3.808
Time – HIV status	0.097	0.117	0.048	0.833	0.405	-0.132	0.326
Nationality	-0.116	0.368	-0.012	-0.316	0.752	-0.838	0.606
HIV sero-status	-0.597	0.376	-0.070	-1.590	0.112	-1.335	0.140

The analysis shows that *HIV infection* was not a significant risk factor for food insecurity among adult residents of refugee settlements in Western Uganda. However, the study site (residence of the research participant) significantly influenced the household food security status of the research participants.

[24] The covariates included in the model had been found during the bivariable analysis to be associated with household food insecurity.

4.5 Anthropometric measurements for research participants for the cross sectional study

4.5.1 Anthropometric status of research participants based on Body Mass Index measurements

The results in **Table 4.15** below show that; the average BMI for participants in this cross sectional study was 22.17 kg / m^2. HIV positive research participants had a significantly lower mean BMI of 21.89 kg/m^2 compared to that of 22.45 kg/m^2 for HIV negative research participants ($p<0.05$).

Similarly, research participants from Nakivale settlement had a significantly lower mean BMI compared to those from Kyaka refugee settlement ($p < 0.05$). Refugees and Ugandan national research participants had comparably similar nutritional status based on their average BMI results ($p>0.05$).

Table 4.15 Mean Body Mass Index for the different groups of research participants

Category	Mean BMI (kg/m^2)	SD	SE	p-value
Combined (N = 736)	22.17	3.51	0.129	
HIV positive (n = 368)	21.89	3.53	0.184	0.029
HIV negative (n = 368)	22.45	3.46	0.184	
Kyaka (n = 368)	22.56	3.44	0.179	0.002
Nakivale (n = 368)	21.78	3.53	0.184	
Ugandans (n = 211)	22.43	3.33	0.228	0.209
Refugees (n = 525)	22.06	3.57	0.156	

In **Table 4.16** below, the results show that overall, nearly 13% of all the research participants in this cross sectional study were underweight while 19% were overweight as measured by their body mass index. Based on HIV status, 15.2% and 10.3% of HIV positive and HIV negative research participants respectively, were underweight according to their BMI measurements and this was statistically significant ($p<0.05$). Furthermore, 18.2% and 20.4% of HIV positive and HIV negative research participants were overweight respectively; the difference was not statistically significant ($p>0.05$).

Table 4.16 BMI categories by HIV status and refugee status[25]

HIV status	BMI category	Refugee status				Total	
		Ugandans		Refugees			
		Frequency	%	Frequency	%	Frequency	%
HIV positive	Overweight	15	15.6	52	19.1	67	18.2
	Normal weight	63	65.6	182	66.9	245	66.6
	Underweight	18	18.8	38	14.0	56	**15.2**
HIV negative	Overweight	28	24.3	47	18.6	75	20.4
	Normal weight	79	68.7	176	69.6	255	69.3
	Underweight	8	7.0	30	11.9	38	**10.3**
Combined	Overweight	43	20.4	99	18.9	142	19.3
	Normal weight	142	67.3	358	68.2	500	67.9
	Underweight	26	12.3	68	13.0	94	**12.8**

[25] Values of BMI for the different categories: Overweight = ≥25.00 kg/m^2; Normal range = 18.50 -24.99 kg/m^2; Underweight = ≤ 18.49 kg/m^2

Table 4.17 show the comparison of the nutritional status form the different categories of participants.

There were 14.5% of the research participants from Nakivale settlement were underweight compared to 11.1% from Kyaka settlement. There were more overweight research participants from Kyaka (21.2%) compared to Nakivale (17.4%) settlement. There was a statistically significant association of underweight and overweight with residence site of the participants ($p<0.05$).

Table 4.17 BMI categories by study site

BMI category	Study site				Total	
	Kyaka		Nakivale			
	Frequency	%	Frequency	%	Frequency	%
Overweight	78	21.2	64	17.4	142	19.3
Normal weight	249	67.7	251	68.2	500	67.9
Underweight	41	11.1	53	14.4	94	12.8

4.5.2 Anthropometric status based on MUAC of research participants

The results in **Table 4.18** indicate that: overall the mean MUAC for all research participants was 26.13cm. There was similarity in the mean MUAC for HIV positive and HIV negative research participants. Research participants from Nakivale settlement had significantly lower mean MUAC compared to those from Kyaka refugee settlement ($p<0.05$). Refugee research participants had a significantly higher MUAC compared to Ugandans who participated in the research.

Table 4.18 Mean MUAC by different groups of participants

Category	Mean MUAC	SD	SE	p-value
Combined (N = 736)	26.13	2.88	0.142	
HIV positive (n = 368)	26.12	2.83	0.147	0.978
HIV negative (n = 368)	26.30	2.63	0.137	
Kyaka (n = 368)	26.37	2.79	0.146	*0.013*
Nakivale (n = 368)	25.88	2.63	0.137	
Refugees (n = 525)	26.27	2.74	0.184	*0.025*
Nationals (n = 211)	25.77	2.67	0.119	

Table 4.19 Cross tabulation of MUAC categories by HIV and refugee status

HIV status	MUAC category	Nationality				Total	
		Ugandans (n = 96)		Refugees (n = 272)			
		Frequency	%	Frequency	%	Frequency	%
HIV positive	Normal MUAC (≥ 24.00cm)	76	79.2	211	77.6	287	78.0
	Malnourished / thin (≤ 23.99cm)	20	20.8	61	22.4	81	22.0
HIV negative	Normal MUAC range (≥ 24.00cm)	87	75.7	212	83.8	299	81.3
	Malnourished / thin (≤ 23.99cm)	28	24.3	41	16.2	69	18.7
Combined	Normal MUAC range (≥ 24.00cm)	163	77.3	423	80.6	586	79.6
	Malnourished / thin (≤ 23.99cm)	48	22.7	102	19.6	150	20.4

The results in **Table 4.19** above show that nearly 21% of the combined research participants had MUAC ≤ 23.99cm. However, based on HIV status, 22.0% and 19% of HIV positive and HIV negative research participants respectively had MUAC ≤ 23.99cm, but the difference was not statistically significant (p>0.05).

Furthermore, the results in **Table 4.20** below shows that: based on HIV status, nearly 24% of the HIV positive research participants from Nakivale settlement had MUAC ≤ 23.99cm compared to 16% of the HIV negative research participants from the same settlement. There was a significant association between HIV status and MUAC category among research participants from Nakivale (p<0.05). However, there was no such difference seen in Kyaka and there was also no difference between HIV positive and HIV negative participants when data from the two sites was combined (p>0.05).

Table 4.20 Cross tabulation of MUAC categories by HIV status and study site

HIV status	MUAC category	Study site				Total	
		Kyaka		Nakivale			
		Frequency	%	Frequency	%	Frequency	%
HIV positive	Normal MUAC range (≥ 24.00cm)	146	79.3	141	76.6	287	78.0
	Malnourished / thin (≤ 23.99cm)	38	20.7	43	23.4	81	22.0
HIV negative	Normal MUAC range (≥ 24.00cm)	144	78.3	155	84.2	299	81.3
	Malnourished / thin (≤ 23.99cm)	40	21.7	29	15.8	69	18.7
Combined	Normal MUAC range (≥ 24.00cm)	290	78.8	296	80.4	586	79.6
	Malnourished / thin (≤ 23.99cm)	78	21.2	72	19.6	150	20.4

4.5.3 Testing Hypothesis 2: HIV infection is a risk factor for malnutrition among adult residents of refugee settlements in Western Uganda.

4.5.3.1 Malnutrition defined by Body Mass Index (BMI ≤ 18.49kg/m^2)

First, using the enter method, I conducted simple linear logistic regression analysis between HIV infection as the Exposure Variable (EV) and malnutrition, defined as *Body Mass Index* ≤ *18.49kg/m^2* as the Outcome Variable (OV). The results indicated that based on BMI, HIV positive research participants were approximately 1.6 times more likely to being malnourished compared to those who were HIV negative and the difference was statistically significant (OR is 1.6, 95% CI: 1.004 – 2.420).

The results in **Table 4.21** below show the multivariable logistic regression analysis of HIV infection (EV) and BMI ≤ *18.49 kg/m^2 (OV)* while adjusting for the following covariates: age, gender, family size, occupation, education status, site of residence, time after knowing HIV positive, nationality, household food insecurity, and dietary diversity. This regression is based on the enter method. The covariates used had been found to be associated with malnutrition during the bivariable analysis.

When adjusted for other variables (covariates), HIV negative research participants were 25% less likely to be malnourished compared to those who were HIV positive but the difference was not statistically significant (OR 0.75, 95% CI: 0.434 – 1.315).

For this cross sectional study I conducted, the results showed that HIV infection was not a risk factor for someone being malnourished. However, based on these results it was only the age of research participants that was found to be a statistically significant risk factor for one being undernourished, as assessed by BMI.

Table 4.21 Logistic regression analysis of HIV infection and malnutrition defined as a BMI≤ 18.49 kg/m^2 (n = 736)

Covariates	B	SE	Wald	df	p	Exp(β)	95% CI	
HIV Infection[26]	-0.280	0.283	0.984	1	0.321	0.756	0.434	1.315
Age	0.036	0.011	11.403	1	*0.001*	1.036	1.015	1.058
Gender	-0.397	0.230	2.989	1	0.084	0.672	0.428	1.055
Family Size	0.115	0.229	0.251	1	0.617	1.121	0.716	1.756
Occupation	0.087	0.256	0.115	1	0.735	1.091	0.660	1.803
Education level	0.152	0.250	0.368	1	0.544	1.164	0.713	1.901
Study site	0.026	0.378	0.005	1	0.946	1.026	0.489	2.152
Time HIV positive	-0.042	0.089	0.222	1	0.637	0.959	0.806	1.142
HFIAS	0.009	0.028	0.102	1	0.750	1.009	0.954	1.067
Nationality	-0.173	0.286	0.365	1	0.546	0.842	0.481	1.473
IDDS	-0.051	0.096	0.281	1	0.596	0.950	0.787	1.147
Constant	-2.999	0.724	17.137	1	0.000	0.050		
Test			X^2	df	p			
Overall model evaluation								
Likelihood ratio test			27.435	12	0.007			
Wald tests			302.672	1	0.000			
Goodness of fit test								
Hosmer & Leweshaw			20.697	8	0.008			

[26] HIV positive = 1 and HIV negative = 2

4.5.3.2 Malnutrition defined using Mid Upper Arm Circumference (MUAC ≤ 23.99cm)

First, I conducted simple logistic regression analysis between HIV infection as the Exposure variable (EV) and Mid Upper Arm Circumference (MUAC)[27] with the cut-off points being as the Outcome Variable (OV) using the enter method. The results for simple logistic regression analysis showed an OR 0.8, which was not statistically significant (p> 0.05).

The results in **Table 4.22** below are from the Multivariable logistic regression analysis using the enter method I conducted with HIV infection as the EV variable and the nutrition status of research participants based on their MUAC as the OV while adjusting for other variables (covariates); age, gender, family size, occupation, education status, health status, site of residence, time after testing positive for HIV, nationality, household food insecurity and dietary diversity.

When adjusted for relevant covariates, HIV positive research participants were 1.3 times more likely to be classified as being malnourished (MUAC ≤ 23.99cm) compared to those who were HIV negative but the difference was not statistically significant (OR 1.3, 95% ; CI: 0.821 – 2.074).

The results from this cross sectional study I conducted showed that HIV sero positivity (infection) was not a risk factor for someone being malnourished, when nutrition status was defined using a low MUAC ≤ 23.99cm.

[27] MUAC ≤23.99cm defined as under nutrition for adults according to Uganda Ministry of Health guidelines

Table 4.22Logistic regression analysis of HIV infection and malnutrition defined as a MUAC≤ 23.99 (n = 736)

Covariates							95% C.I. for EXP(B)	
	B	**SE**	**Wald**	**df**	**Sig.**	**Exp(B)**	**Lower**	**Upper**
Age	0.002	0.009	0.046	1	0.829	1.002	0.984	1.021
Gender	0.335	0.189	3.164	1	0.075	1.399	0.966	2.024
Family size	0.050	0.189	0.069	1	0.793	1.051	0.726	1.522
Occupation	0.367	0.215	2.908	1	0.088	1.443	0.947	2.201
Education level	-0.049	0.212	0.053	1	0.818	0.952	0.628	1.444
Health status	-0.186	0.217	0.740	1	0.390	0.830	0.543	1.269
Study site	0.341	0.297	1.322	1	0.250	1.406	0.786	2.515
Time - HIV positive	0.068	0.072	0.890	1	0.345	1.070	0.930	1.232
HIV infection	0.266	0.236	1.266	1	0.261	1.305	0.821	2.074
HFIAS	-0.011	0.023	0.212	1	0.645	0.989	0.946	1.035
Nationality	0.170	0.224	0.571	1	0.450	1.185	0.763	1.839
IDDS	0.089	0.077	1.344	1	0.246	1.093	0.940	1.271
Constant	0.328	0.592	0.308	1	0.579	1.389		
Test			X^2	df	p			
Overall model evaluation								
Likelihood ratio test			12.635	12	0.396			
Wald tests			27.769	1	0.000			
Goodness of fit test								
Hosmer & Leweshaw			6.078	8	0.638			

4.6 Results from Hand Grip Strength measurements

In the **Table 4.23** below I have highlighted the results of Hand Grip Strength (HGS) for the different groups of research participants.

The results in **Table 4.23** below show that: underweight (either BMI ≤ 18.49 kg/m^2 or MUAC ≤ 23.99 cm) research participants had significantly lower HGS scores (17.5) compared to those with 'normal' nutritional status as categorized by their BMI or MUAC.

There was not significant differences in the mean HGS scores for HIV positive and HIV negative participants (p>0.05).

Table 4.23Mean Hand Grip Strength (HGS) for different sub-groups of participants

Category	Mean HGS Score	SD	SE	p-value
Combined (N = 736)	20.38	6.78	0.249	
HIV positive (n = 368)	20.23	6.63	0.346	
				0.550
HIV negative (n = 368)	20.53	6.93	0.361	
BMI ≤ 18.49 kg/m^2 (n = 94)	17.43	4.39	0.454	
				0.000
BMI ≥ 18.50 kg/m^2 (n = 641)	20.83	6.96	0.275	
MUAC ≥ 24.00 cm (n = 586)	20.43	6.86	0.284	
				0.692
MUAC ≤ 23.99 cm (n = 150)	20.18	6.46	0.527	

After conducting correlations between HGS and nutrition status based on MUAC and BMI separately, the results are indicated in **Table 4.24** below. The results showed that hand grip strength was positively and significantly correlated with BMI among HIV positive participants but not those who were HIV negative.

Table 4.24 Correlation between Hand Grip Strength and Nutritional status for participants of cross sectional study

HIV Status	Correlation coefficients / Nutritional status	
	BMI	**MUAC**
HIV positive	0.298**	0.084
HIV negative	0.015	-0.023
Combined	0.156**	0.031

**These correlations were significant at $p < 0.05$.

4.7 Results of Bioelectrical Impedance Analysis parameters for participants of the cross sectional study

Below, I present results of bioelectrical impedance data for the different categories of participants. First, I provide the descriptive analysis for BIA based on the HIV sero-status of participants. Thereafter, I provide BIVA graphs for different categories of participants.

4.7.1 BIA parameters for participants for cross sectional study

The results in the **Table 4.25** below show differences in the BIA parameters for participants based on their HIV sero-status. The mean values for phase angle were higher for HIV negative compared to HIV positive. Overall, despite the differences in all the other BIA parameters for

HIV positive and HIV negative participants, the differences observed were not statistically significant

Table 4.25Description of BIA parameters based on HIV sero-status (N= 736)

Variable	HIV Status						P - value
	HIV Positive			HIV Negative			
	Mean	SD	SE	Mean	SD	SE	
Phase angle	5.86	0.87	0.457	5.92	0.81	0.803	0.340
Reactance	61.74	9.66	0.504	62.64	9.23	0.481	0.193
Resistance	605.98	98.09	5.113	611.46	90.11	4.697	0.430
Impedance	609.24	98.99	5.161	617.40	87.02	4.536	0.235
Reactance / Height	38.14	6.89	0.359	38.75	66.33	3.457	0.430
Resistance / Height	374.56	69.82	3.639	378.61	66.33	3.457	0.430
H^2/Impedance	45.02	10.19	0.532	43.99	9.23	0.4811	0.155
1/Impedance[28]	16.85	3.70	0.14	16.52	2.33	0.13	0.081
Illness Marker	0.79	0.33	0.017	0.79	0.028	0.0015	0.802

4.7.2 Bioelectrical Impedance Vector Analysis for different groups of participants for the cross sectional study

I used the values of Resistance and Reactance adjusted for height (R/H and Xc/H) to generate the R/Xc graphs using the bioelectrical impedance vector analysis as was described by Piccoli [39].

[28] Values have been multiplied with 10,000

4.7.2.1 BIVA graphs for male participants for the cross sectional study based on their sero-status

Based on the results in **Table 4.26** below, I plotted the RXc graph to show the difference between the BIVA for male participants based on their HIV status.

Table 4.26 Bioelectrical impedance data based on HIV status of male participants of cross sectional study

Group and size	Weight	Height	Resistance /Height	Reactance/ Height	Pearson's coefficient (r)
HIV positive (136)	59.1±7.4	1.66±0.1	336.5±59.2	35.6±5.8	0.45
HIV negative (137)	59.9±7.7	1.62±0.1	342.6±51.3	36.7±5.3	0.62

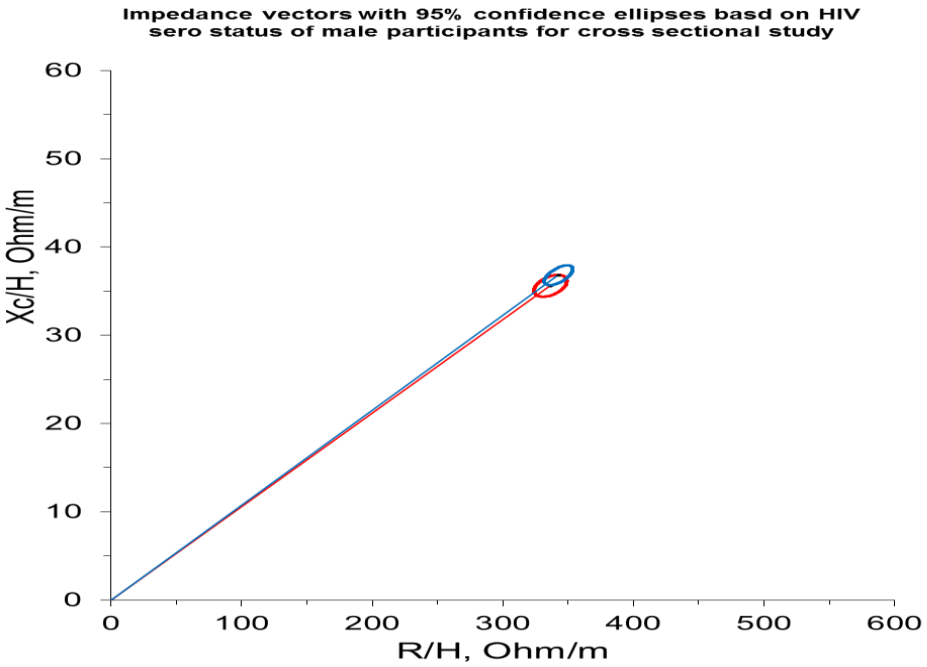
I used the BIVA Software 2002[29] to plot the data for the male and female participants based on their HIV sero-status as indicated in **Figure 4.1** and **Figure 4.2** below. The R/Xc graphs generated are considered to show the status of cell tissue hydration and cell mass[30] of the participants being considered

The BIVA for male participants based on their HIV sero-status is illustrated in Figure 4.1 below. The red graph is for HIV positive while the blue is for HIV negative male participants. There is minimal difference in the BIVA for the two groups with similarity in the values for R/H, Xc/H and phase angle.

[29] Piccoli A, Pistori G: BIVA Software 2002. Department of Medical and Surgical Sciences, University of Padova, Padova, Italy, 2002. Available at E-Mail: apiccoli@unipd.it [174].

[30] Displacements of vectors parallel to the higher axis of tolerance ellipses indicate progressive changes in tissue hydration. Long vectors, above the upper pole, indicate dehydration; while short vectors, below the lower pole, indicate hyper hydration with apparent oedema. Vectors descending or migrating parallel to the minor axis indicate the amount of cell mass: above displacements (to the left) indicate higher amount of cell mass; below displacements (to the right), indicate smaller amount of cell mass [174].

Figure 4.1 BIVA confidence graphs based on the HIV sero-status of male participants for cross sectional study



4.7.2.2 BIVA graphs for Female participants for the cross sectional study based on their HIV sero-status

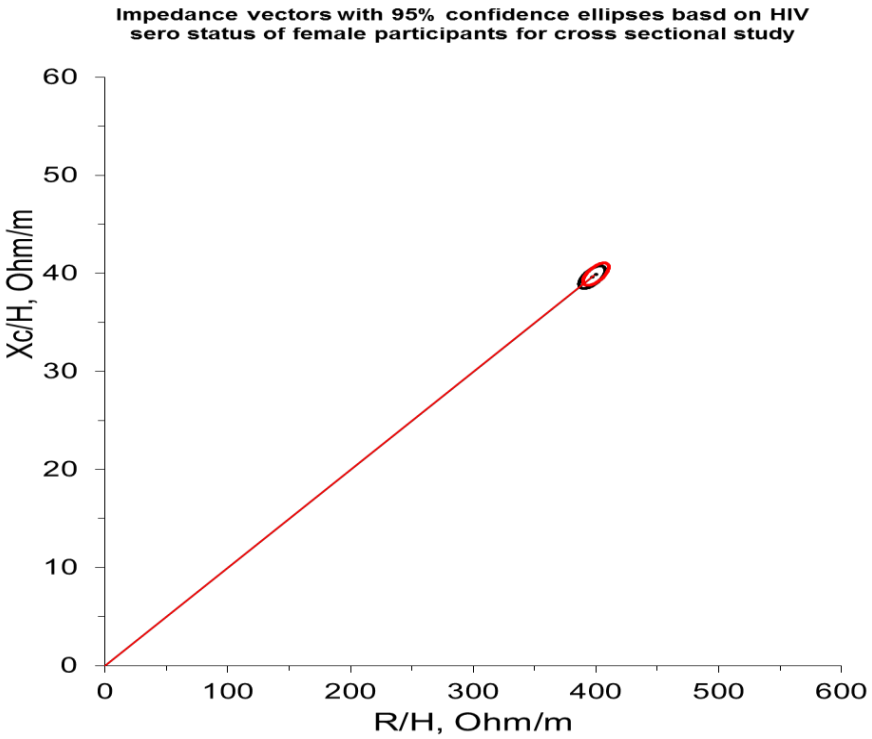
Based on the results indicated in **Table 4.27** below, I plotted the R/Xc graph for the BIVA for the female participants based on their HIV sero-status.

Table 4.27 Bioelectrical impedance data based on HIV status of female participants of cross sectional study

Group and size	Weight	Height	Resistance /Height	Reactance/ Height	Pearson's coefficient (r)
HIV positive (232)	58.6±9.9	1.57±0.1	396.8±65.9	39.6±7.1	0.62
HIV negative (231)	58.9±10.5	1.57±0.1	399.9±65.1	39.9±7.1	0.64

The graph shows minimal difference between the HIV positive (red graph) and HIV negative (black graph) participants as they have similarities in the resistance, reactance and phase angle.

Figure 4.2 BIVA confidence graphs based on the HIV sero-status of male participants for cross sectional study



4.7.3 Relationship between nutritional status and selected BIA parameters stratified by gender

In the **Tables 4.28** and **Table 4.31** below, I have highlighted the results of the selected BIA parameters based on gender of participants and in relation to their nutritional status as indicated by body mass index categories.

I decided to stratify the BIA parameters based on the participants' gender because previous studies have shown that BIA parameters differ by sex [38].

4.7.3.1 BIA parameters for male participants based on their nutritional status

The results in **Table 4.28** below show that there were statistically significant differences in Phase Angle, Reactance, Reactance / Height and H2/Impedance parameters for those who were underweight (BMI = ≤ 18.49kg/m2) compared to those with normal weight (BMI = ≥ 18.50kg/m2) ($p<0.05$).

Table 4.28 Mean values for selected BIA parameters for male participants (N = 272)

Variable	Underweight (BMI = ≤ 18.49kg/m^2) (n = 43)			Normal weight (BMI = ≥ 18.50kg/m^2) (n = 229)			p-value
	Mean	SD	SE	Mean	SD	SE	
Phase angle	5.79	1.31	0.199	6.22	0.76	0.051	*0.004*
Reactance	58.06	9.98	1.53	60.94	7.71	0.509	*0.033*
Reactance / Height	33.61	5.94	0.905	36.67	5.37	0.355	*0.001*
Resistance	582.09	103.97	15.85	564.88	75.05	4.961	0.198
Resistance / Height	337.49	65.18	9.941	340.11	53.48	3.534	0.778
Impedance	585.53	103.01	15.71	569.76	76.58	5.061	0.244
H^2/Impedance	52.86	10.56	1.611	50.00	9.07	0.599	0.066
1 / Impedance [31]	17.6	2.8	2.8	17.8	2.4	0.16	0.460

4.7.3.2 BIVA graphs for male participants for cross sectional study based on their nutritional status

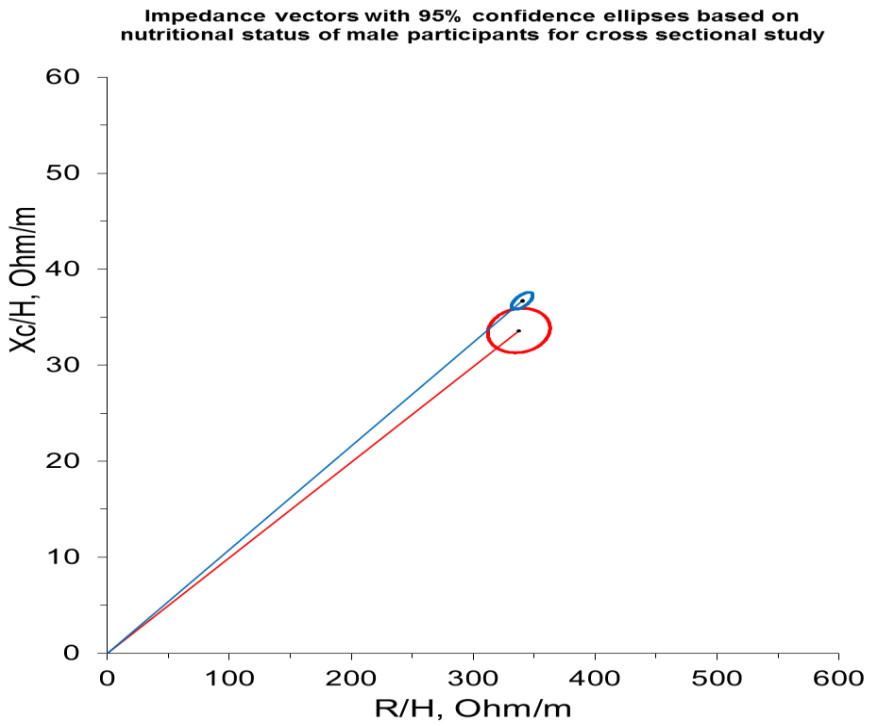
I plotted the RXc graphs for the male participants based on their nutritional status as per the BIA data in the **Table 4.29** below and the BIVA graph is illustrated in **Figure 4.3** below.

[31] 1/Impedance – results were multiplied by 10,000

Table 4.29 Bioelectrical impedance data based on nutritional status of male participants of cross sectional study

Group and size	Weight	Height	Resistance /Height	Reactance/ Height	Pearson's coefficient (r)
Male - underweight (43)	52.4±5.1	1.71±0.1	337.5±65.2	33.6±5.9	0.12
Male – normal weight (230)	60.8±7.1	1.69±0.1	340.2±53.5	36.7±5.4	0.64

Figure 4.3 BIVA confidence graphs based on the nutritional status of male participants for cross sectional study



The results illustrated in **Figure 4.3** above are for underweight participants - red graph - and those with 'normal' weight (BMI≥18.5kg/m^2) – blue graph. Male participants who were underweight had significantly lower values of reactance and phase angle compared to those who had normal weight. However, there was similarity in the values of their resistance.

4.7.3.3 BIA parameters of female participants for cross sectional study based on their nutritional status

Results in Table 4.30 show that underweight participants had lower values of reactance, phase angle but higher resistance and impedance compared to females who had normal weight. Apart from the reactance, the differences of all the BIA values below were statistically significant.

Table 4.30 Mean values for selected BIA parameters for female participants (N = 463)

Variable	Underweight (BMI = ≤ 18.49kg/m^2) (n = 51)			Normal weight (BMI = ≥ 18.50kg/m^2) (n = 412)			p-value
	Mean	SD	SE	Mean	SD	SD	
Phase angle	5.16	0.83	0.116	5.82	0.739	0.036	*0.000*
Reactance	62.72	9.79	1.374	63.26	10.04	0.495	0.722
Reactance / Height	38.72	6.45	0.903	39.92	7.11	0.349	0.252
Resistance	701.37	10.49	14.695	624.61	88.36	4.353	*0.000*
Resistance / Height	433.16	70.89	9.932	394.13	63.52	3.129	*0.000*
Impedance	709.45	100.08	14.014	628.74	86.28	4.251	*0.000*
H^2/Impedance	38.15	7.45	1.043	41.34	8.13	0.400	*0.008*
1 / Impedance	14.4	2.07	0.29	16.2	2.3	0.12	*0.000*

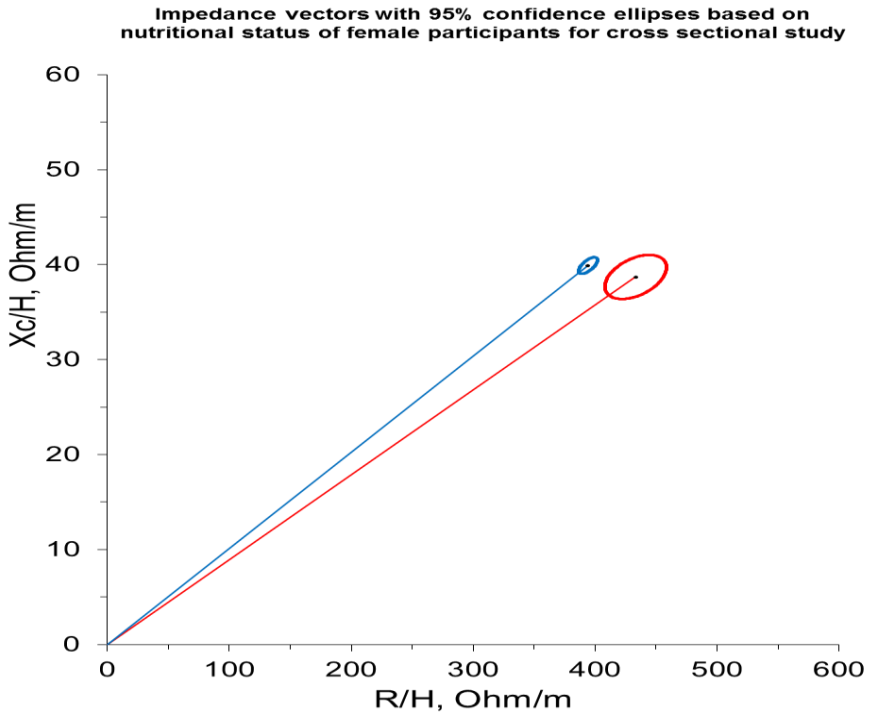
4.7.3.4 BIVA graphs for female participants for cross sectional study based on their nutritional status

Using the BIA data in **Table 4.31** below, I plotted the RXc graphs for BIVA for female research participants based on their nutritional status.

Table 4.31 Bioelectrical impedance data based on nutritional status of female participants of cross sectional study

Group and size	Weight	Height	Resistance /Height	Reactance/ Height	Pearson's coefficient (r)
Female - underweight (51)	45.6±9.6	1.61±0.1	433.2±70.8	38.7±6.5	0.44
Female – normal weight (412)	59.4±5.2	1.59±0.1	394.2±63.5	39.9±7.2	0.67

Figure 4.4 BIVA confidence graphs based on the nutritional status of female participants for cross sectional study



The red graph is for underweight female participants while the blue one is for those with normal weight. The underweight participants had lower mean values for reactance and phase angle and significantly higher mean value for resistance compared to those with normal weight.

4.7.4 Testing Hypothesis 3: HIV infection is associated with differences in bioelectrical impedance parameters among adult refugees in settlements in Western Uganda.

To test hypothesis 3, I investigated the effect of HIV infection on five bioelectrical impedance parameters. These were: Phase Angle, Reactance / Height, and Resistance / Height, H^2 / Impedance and 1/Impedance.

The Exposure Variable (EV) was HIV infection while the selected BIA parameters (Phase angle, Reactance / Height, Resistance / Height, H^2 / Impedance, and 1/ Impedance) were the Outcome Variables. The other covariates considered in the model were; age, sex, height[32], weight, health status, time after testing HIV positive, household food insecurity, dietary diversity, study site, and nationality.

First I conducted linear regression analysis (bivariable) as an exploratory analysis to understand the link between the EV and OV at the bivariable level. I then conducted multivariable analysis with all the covariates (age, sex, height, weight, health status, time after testing HIV positive, household food insecurity, dietary diversity, study site, and nationality) included in the model using the enter method.

I have presented the results of the regression analysis, first for the combined research participants and secondly after disaggregation based on the gender of the research participants.

4.7.4.1 Results for combined research participants

As shown in **Table 4:32**, the results from bivariable linear regression analysis indicate that HIV infection was not significantly associated with a difference in any of the selected BIA parameters. For multivariable regression analysis, results showed that HIV infection was significantly associated with Resistance/Height, H^2/Impedance and 1/Impedance ($p<0.05$). This is highlighted in the two tables below.

[32] Height was not included as one of the covariate for reactance / height, resistance / height and h^2 / impedance.

Table 4.32 Linear regression analysis of the effect of HIV infection on BIA parameters in participants from the cross-sectional study (n=736)

Outcome Variable	Analysis[33]	R^2	F	B	p value	95% CI
Phase angle	Bivariable	0.001	0.912	0.035	0.340	-0.063, 0.181
	Multivariable	0.196	16.037	-0.046	0.278	-0.218, 0.068
Reactance / Height	Bivariable	0.002	1.498	0.045	0.221	-0.368, 1.586
	Multivariable	0.217	20.109	0.067	0.110	-0.205, 2.014
Resistance / Height	Bivariable	0.001	0.650	0.030	0.420	-5.807, 13.903
	Multivariable	0.442	57.372	0.117	*0.001*	6.507, 25.399
H^2/Impedance	Bivariable	0.003	2.031	-0.053	0.155	-2.429, 0.386
	Multivariable	0.497	71.726	-0.0129	*0.000*	-0.000, 0.000
1/Impedance	Bivariable	0.004	3.044	-0.064	0.081	-0.000, 0.000
	Multivariable	0.322	34.503	-0.182	*0.000*	-0.000, 0.000

R^2 = R squared; F = F test; β = Standardized beta coefficient; 95% CI = 95% Confidence Interval

4.7.4.2 Results of participants when stratified by gender

Results for regression analysis conducted are shown in **Table 4.33** and **Table 4.34** below. The results indicated that for both male and female research participants showed that after adjusting for covariates, HIV infection was significantly associated with differences in phase angle, resistance / height, H^2/Impedance and 1/impedance ($p<0.05$).

[33] Covariates included: age, gender, weight, height, family size, education status, occupation, health status, site of residence, time after testing HIV positive and nationality. Height was excluded when conducting multivariable analysis for Reactance / Height, Resistance / Height and H^2/Impedance.

Table 4.33 Linear regression analysis of the effect of HIV infection on BIA parameters in male participants from the cross-sectional study (n=273)

Outcome Variable	Analysis	R^2	F	β	p value	95% CI
Phase angle	Bivariable	0.001	0.317	0.034	0.574	-0.151, 0.272
	Multivariable	0.622	45.687	-0.160	*0.001*	-4.796, -1.192
Reactance / Height	Bivariable	0.012	3.244	0.109	0.073	-0.112, 2.526
	Multivariable	0.169	5.963	0.046	0.534	-1.102, 2.124
Resistance / Height	Bivariable	0.003	0.817	0.055	0.367	-7.132, 19.243
	Multivariable	0.423	21.453	0.128	*0.038*	0.765, 27.515
H^2/Impedance	Bivariable	0.001	3.167	-0.107	0.076	-4.227, 0.213
	Multivariable	0.456	26.318	-0.147	*0.013*	-4.912, -0.592
1/Impedance	Bivariable	0.005	1.453	-0.073	0.229	0.000, 0.000
	Multivariable	0.315	13.428	-0.209	*0.002*	0.000, 0.000

Table 4.34Linear regression analysis of the effect of HIV infection on BIA variables among female participants from the cross-sectional study (n=463)

Outcome Variable	Analysis	R^2	F	β	p value	95% CI
Phase angle	Bivariable	0.001	0.619	0.037	0.432	-0.085, 0.199
	Multivariable	0.636	50.647	-0.136	*0.001*	-3.499, -0.902
Reactance / Height	Bivariable	0.000	0.173	0.019	0.678	-1.014, 1.559
	Multivariable	0.173	20.563	0.068	*0.029*	-0.537, 2.445
Resistance / Height	Bivariable	0.001	0.263	0.024	0.609	-8.844, 15.083
	Multivariable	0.289	20.440	0.124	*0.013*	3.387, 29.107
H^2/Impedance	Bivariable	0.012	0.409	-0.030	0.523	-1.963, 1.000
	Multivariable	0.201	12.701	-0.183	*0.001*	0.000, 0.000
1/Impedance	Bivariable	0.005	2.093	-0.067	0.149	0.000, 0.000
	Multivariable	0.306	22.149	-0.136	*0.006*	-3.784, -0.636

R^2 = R squared; F = F test; β = Standardized beta coefficient

Chapter 5. Discussion of results from the cross sectional study of HIV positive and HIV negative residents of Kyaka and Nakivale refugee settlements

Introduction

In this chapter I highlight and discuss the key results from the cross sectional study. The discussion focuses on the study hypotheses and the related research questions plus the corresponding study objectives.

I have structured the discussion based on the results that I got for household food insecurity, dietary practices, anthropometric measurements, hand grip strength and bioelectrical impedance analysis.

5.1 Household food insecurity, dietary practices and malnutrition among research participants of the cross sectional study

Food insecurity, poor dietary diversity and malnutrition - both undernutrition and over nutrition - were common among the research participants from Nakivale and Kyaka refugee settlements in South Western part of Uganda.

5.1.1 Household food insecurity is widespread but affecting some specific groups more compared to others

Food insecurity was widespread among the participants of this study with more than half of the (54% of participants) coming from households categorized as being food insecure based on the HFIAS score. However, there were geographical differences observed with more participants from Nakivale refugee settlement coming from food insecure households compared to those from Kyaka refugee settlement ($p<0.05$). Similarly, there were differences in household food insecurity based on HIV status and nationality of the participants with HIV positive participants

and refugees coming from food insecure households compared to HIV negative participants and Ugandan nationals; and this was true for both Nakivale and Kyaka refugee settlements.

The WHO and FAO definition of food security includes food availability, food access, and utilization [175,176]. In this study, I assessed the food access component of household food insecurity using the Household Food Insecurity Access Scale (HFIAS) tool. The HFIAS tool has been validated by FAO and FANTA, with further studies done which have also found it to be simple and sensitive in the identification of food insecure households [168]. Hoddinott mentions that at the individual or household level food access and its utilization could be constrained by economic and social factors preventing somebody getting the food they need of the right quality and quantity [177]. Previous studies like one carried out among HIV infected Rwandese women showed an association of extreme poverty and illiteracy with food insufficiency [178]. For Kyaka settlement, a household having 5 or more people was significantly associated with poor food insecurity among HIV positive participants, although this was not seen for Nakivale participants maybe because food insecurity was generalized affecting more than 60% of the participants within the settlement. Furthermore, having had no formal education was associated with household food insecurity among HIV negative participants of Kyaka study. Otherwise, all the other socioeconomic characteristics were not significantly associated with household food security access for participants of Kyaka and Nakivale settlements.

The poor health status of PLHIV has been associated with household food insecurity because when people with HIV become ill, there is likely to be an immediate strain on the person's ability to work, feed themselves and provide care to the family especially if it is the household's most productive member who is infected with HIV [179]. In this study, there were more HIV positive participants who reported as having been (with poor health) during the past four weeks before the interview compared to HIV negative participants and the difference was statistically

significant. The high 'prevalence of poor health' seen among HIV positive participants interviewed during the study might be an underlying cause for food insecurity as those who are sick are less productive, enable to actively engage in any meaningful daily livelihood activities and sometimes having to spend their meagre finances on medications towards treating their different ailments and leaving them with less income to buy food and other necessities they may require. The situation could even be worsened when the sickness are chronic especially in the case of HIV infection and the associated opportunistic infections like TB.

In Uganda food insecurity is common among many people and especially those living with HIV and other chronic diseases despite the country being considered a 'food basket' for the region [129,130]. This has been attributed to many factors including; lack of money to purchase the required foods, inadequate knowledge on how to effectively utilize the available foods, and sometimes HIV positive adults unable to grow their own foods because of limited strength due to the effect of HIV and other opportunistic diseases [180,181]. In this study, although I inquired about the economic activities the research participants were engaged in, I was unable to have an in-depth assessment of their economic status and issues concerning their expenditures on foods purchased to supplement food supplies from WFP (for the refugees), other livelihood activities they or their household members are engaged in and assets they have and access to and utilisation of arable land they have which might be affecting their abilities to have adequate foods.

Refugees who formed the bulk of the cross sectional study are known to be economically vulnerable with limited financial resources [182]. Their food security situation may be worsened by not having adequate land to grow their foodstuffs and most of the times depending on food aid which may greatly affect their abilities to have enough quantity and variety of food supplies [182]. Not having adequate arable land for cultivation and limited opportunities to engage in

different livelihood activities has been reported as being common in Nakivale refugee settlement hence this might affect the residents abilities to access to their required and preferred foods and hence the high household food insecurity seen. These observations could be the reason why there was significantly higher household food insecurity in Nakivale compared to Kyaka refugee settlement.

The high household food insecurity seen among residents of Nakivale, HIV positive adults and refugees could be a great risk factor to the nutritional status of these populations. In this study, the multivariable analysis showed that HIV infection was not a risk factor to poor household food insecurity among the participants studied. This finding is not like what has been observed in other studies done among PLHIV [123,126]. However, among the participants studied, geographical location was a significant factor with the possible reasons for this as explained above.

5.1.2 Poor dietary diversity was common among research participants

Overall, dietary diversity was poor among all participants assessed during this cross sectional study where the mean IDDS was 3.56 (SD = 1.55). There were more than half (53.7%) of the participants within the low dietary diversity category (having eaten foods from less than three food groups the day preceding the interviews).

As was observed with household food insecurity, there were geographical differences where participants from Nakivale refugee settlements had significantly low IDDS with a mean of 2.76 (SD=1.12) compared to those from Kyaka refugee settlement with IDDS mean of 4.39 (SD=1.52). Furthermore, being HIV positive meant having lower IDDS of 3.38 (SD = 1.3) compared HIV negative participants with means of 3.38 (SD=1.15). Refugees also had

significantly low IDDS compared to Uganda nationals of 3.31 (SD=1.45) and 4.23 (SD=1.63) respectively.

The results from the cross sectional study showed a similar picture with over 80% of the participants having had diets largely made of cereals and pulses and fewer people eating animal proteins, fruits and vegetables. The poor dietary diversity and the limited food intake (as per the number of meals eaten) observed especially among those who are HIV positive may have greater repercussions for their health and wellbeing. These findings are similar to other dietary diversity studies done within Uganda in general and among refugees from Kyaka and Nakivale settlements [123,133]. For example, according to the Uganda 2010 Country Nutrition Profile conducted by FAO, the Ugandan diet was considered to be insufficiently diversified with many people consuming only starchy food stuffs (cereals and roots) and pulses and nuts [183]. The low number of people that eat fruits and vegetables is worrying considering the known benefits of these foods in improving one's immunity and hence prevent repeated opportunistic infections [183].

Like in many other communities and countries, even in Uganda poor dietary diversity has been associated with low socioeconomic status, inadequate nutrition knowledge and illness [123,183,184]. People with high income in relation to their peers within their communities have been found to have the economic ability to purchase different types of foods from different food groups whereas those with low income only eat the cheaper available foods hence limiting them having dietary diversification [112]. In Nakivale refugee settlement, having no occupation was associated with even poorer dietary diversity especially among the HIV positive participants. Otherwise, all the other demographic and socioeconomic characteristics were not associated with the levels of dietary diversity for observed. The observed findings of no association between

dietary diversity and other demographic and socioeconomic factors could be because of poor dietary diversity being widespread hence affecting most categories of people.

It is known that HIV attacks the immune system of the affected person and for the body to be able to fight back; it requires an increase in energy and nutrients [23]. Similarly, people infected with HIV need to eat more foods and of varying varieties to meet their extra energy demands and nutrient requirements [23]. This information is usually provided to PLHIV during the nutrition counselling, but as the results showed, many HIV positive people in the two study sites had poor dietary diversity. This could be detrimental to the quick improvement of the health and nutritional status of the participants especially those with infectious diseases including HIV which have been observed to affect the nutritional status of people [28]. This study did not investigate the nutrition knowledge of the participants as well as the reasons and factors why people ate the kind of foods that they mentioned. It is worth noting that there was an association of the number of meals eaten and the dietary diversity which could point to limited availability of foods being a great contributor to the few food groups eaten.

The findings of the poor dietary diversity from the cross sectional study are similar to those that have been observed among PLHIV in many other settings [107,108]. The results from Kyaka refugee settlement are comparable with others observed among PLHIV in Uganda. However, the results from Nakivale settlement show a worse situation. Apart from the poor diversity in the foods eaten, in Nakivale settlement participants also had less number of meals eaten and hence limited food intake. This could be due to the difficulties refugees face first in getting food as majority are depending on food aid and having limited money or resources to buy additional foodstuffs or with limited land to cultivate foods of their own. These challenges could be experienced more by refugees in Nakivale settlement which is in a semi-arid area within limited access to arable land as compared to those in Kyaka settlement [186]. The limited food eaten as

observed in the number of meals eaten as well as the diversity of the foods is also an indication of the participants' limited access to food hence their household food insecurity access. As has been indicated by other researchers, dietary diversity hence becomes a measure of household food insecurity access [177].

It has been previously noted that food intake is affected by the HIV illness itself, poor or loss of appetite due to the medications, inadequate food supply especially among PLHIV [23]. There was association of the poor health status especially among HIV positive participants with poor dietary diversity. In Uganda, some studies have shown that despite households having enough food supplies, poor dietary diversity is common and linked to malnutrition especially among children [129,183]. However, in this study I was not able to assess the research participant's' knowledge about nutrition in general and to know if they are aware of the recommended feeding practices for PLHIV.

5.1.3 Household food insecurity linked with dietary diversity and nutrition status of participants

From Kyaka refugee settlement, household food insecurity was associated with poor dietary diversity among HIV positive participants but not with HIV negative participants. However, for Nakivale refugee settlement, despite the high number of participants having high food insecurity and poor dietary diversity, no statistically significant association was observed between the two. This lack of association has also been observed in a study conducted among Rwandese HIV positive and HIV negative women. Sirotin et al, found food insufficiency of 46%, low dietary diversity of 43% and low BMI of 15% but there was no correlation of the three with each other. This made them to suggest that BMI alone may not be an adequate screening tool for food insufficiency as was no very indicative of the overall nutrition status of PLHIV [178].

Food access and diet quality have been associated with the quality of life outcomes among HIV positive adults in Uganda [126]. It has also been observed that food security and dietary diversity do affect the capacity of PLHIV to adhere to the medications prescribed, and this has been observed in both resource rich and resource poor countries and communities [127]. In this cross sectional study I did not assess HIV positive participants' adherence to their HIV medications. But, nevertheless there was an association observed between poor dietary diversity, household food insecurity and poor health status among HIV positive participants. This association could be an indication that access to food and its proper utilization might be a factor in the health and wellbeing of HIV positive adults. It might also indicate that HIV positive patients who have a secondary infection (and therefore do "not feel well") might not be able to access food or have an appetite for eating it. Indeed, it may be that HIV positive patients whose CD4 counts were controlled by ARTs or had not yet fallen sufficiently to allow secondary infection to occur were well able to maintain their nutritional status. This might explain the lack of association between sero-positivity and malnutrition but an evident correlation between "not feeling well" and malnutrition. It would have been interesting to know the CD4 status of the patients but CD4 counts were not being measured at the time of the study.

The number of unique foods consumed as measured by the individual dietary diversity score has been found to be a useful approach to measuring household food access [177]. In this cross sectional study, the association of poor dietary diversity and household food insecurity may be an indication of the effect food access has on the quality and diversity of foods eaten by the participants in Nakivale and Kyaka refugee settlements. In this study I did not measure the quantity and composition of the foods that were eaten by the participants. However, based on the different categories of the foods eaten of mainly starchy cereals or roots and pulses (beans or ground nuts), it is could be believable that the foods eaten lacked nutrition sufficiency for the well-being and health of the participants.

5.1.4 HIV infection being a risk factor for food insecurity among adult residents of refugee settlements in southwestern Uganda.

In this study as has been described above, HIV infection was not a risk factor for household food insecurity. However, the residence of that participants significantly influenced their household food security status. This geographical effect observed where Nakivale residents had higher household food insecurity compared to those from Kyaka settlement could be attributed to the limited available and accessible to arable land for agriculture and livelihood opportunities. This meant that participants had limited access to food because of their limited incomes. It should be noted that there other studies done which demonstrated that HIV infection was a risk for food insecurity [123].

Despite not showing that HIV infection was a risk factor to household food insecurity in the population studied, refugees living with HIV especially those from Nakivale settlement may be vulnerable considering that they have limited access to food as well as other livelihood opportunities. This vulnerability and risk associated with HIV infection may increase especially for refugees who might be not having good social and economic networks to support them. Furthermore, HIV infection with its effect on the body might lead to reduced productivity although in this study that was not observed based on the hand grip strength analysis that I conducted, there was no association observed between HIV infection and changes in hand grip strength of the participants.

5.1.5 Nutrition status of participants – both undernutrition and over nutrition were common

Malnutrition based on the Body Mass Index (BMI) measurements was common among participants from both Kyaka and Nakivale refugee settlements. However, HIV positive participants had proportionately higher malnutrition prevalence compared to HIV negative

participants. This was true for both male and female research participants. It was also observed that obesity (BMI $\geq$ 25.00 kg/m^2) was common and even more prevalent compared to undernutrition among both HIV positive and HIV negative research participants within the two study sites. There were also geographical differences observed as participants from Nakivale refugee settlement had relatively higher malnutrition prevalence rates compared to those from Kyaka refugee settlement 14.4% and 11.4% respectively).

The malnutrition rates observed in the cross sectional study are comparable to what has been previously reported within the general population of south-western Uganda and more specifically for women aged 15 -49 years as according to the 2006 and 2011 Uganda Demographic and Health Surveys (UDHS) [186,187]. Similarly, the malnutrition prevalence seen in the two refugee settlements was in range with that obtained from analysing demographic and nutrition surveys undertaken by the United Nations Administrative Committee on Coordination Sub-Committee on Nutrition (ACC/SCN) in which 10% - 20% of African women 20 – 49 years of age were malnourished (mean BMI, < 18.5 kg/m^2) [188].

The finding of higher prevalence of malnutrition among HIV positive participants compared to HIV negative participants was similar to that of other studies done where comparisons have been done based on the HIV sero-status of the research participants. For example the prevalence of malnutrition of 14% and 16.8% among HIV positive research participants that I found in my study was similar to that which was observed in one cross-sectional study conducted by Hailemariam S, Bune GT, et al among HIV patients aged 18 years or above attending the HIV clinic in Dilla University referral hospital in Ethiopia, where malnutrition prevalence was estimated at 12.3% (95% CI 9.5 – 15.0) [189]. However, HIV positive adults in Kyaka and Nakivale refugee settlements had slightly higher malnutrition rates compared to the 10.3% which Olalekan got when he analysed DHS data sets from 11 African countries for HIV positive women [74]. It is worth noting that the rates of malnutrition among HIV positive adults in Kyaka

and Nakivale refugee settlements were lower compared to the rates observed for studies done in Botswana and Zambia which had 30% of PLHIV being malnourished (BMI <18.5 kg/m^2) [72,72].

5.1.6 HIV infection being a risk factor for malnutrition among adult residents of refugee settlements in Western Uganda

In this cross sectional study, HIV infection was found to be a risk factor for malnutrition among HIV positive participants. It was observed that HIV positive participants were 1.6 times more likely to be malnourished compared to those who were HIV negative with the difference being statistically significant. For the HIV negative participants, it was observed that they were 25% less likely to getting malnourished compared to the HIV positive participants but this was not statistically significant.

The relationship between HIV infection and malnutrition has been recognized since the early days of the disease where it was referred to as the 'slim' disease in Uganda [1]. Nutrition and HIV are interrelated since any immune impairment as a result of HIV/AIDS leads to malnutrition and malnutrition leads to immune impairment which worsens the effect of HIV and contributes to more rapid progression to AIDS [2].

Among HIV positive participants in this study, the risk of HIV infection could even be heightened because of their poor health status and repeated infections they had in the past four weeks. The poor health due to opportunistic infections like oral sores, vomiting, diarrhoea among others could cause them to have poor appetite or increased metabolic demands on their bodies and poor absorption of the foods eaten hence leading to malnutrition as has been observed in other studies [23]. In this study I did not assess the CD4 count nor the HIV viral load of the HIV positive participants[34]. This could have provided the level of immunity and HIV infection

[34] Assessing CD4 count and viral load was not routinely done at the time of conducting the study.

which could be related to the nutrition status providing a deeper understanding of the linkage between HIV infection, immunity and nutrition status of HIV positive participants.

5.1.7 Nutritional status and its effect on the functionality of research participants

In this cross sectional study, Hand Grip Strength (HGS) was significantly lower among those participants who were underweight (BM1 $\leq$ 18.5kg/m^2) compared with those with 'normal' nutrition status. There was a positive correlation between HGS and nutrition status of the participants irrespective of their HIV status.

Norman and colleagues have studied HGS as a nutritional marker suggesting that it (HGS) would be a good indicator of nutrition status [190]. Furthermore, HGS has been associated with Physical Activity Level (PAL) which would measure the ability of the individual to participate in daily activities [191-193]. Unfortunately in this study, we did not assess the physical activity levels of the research participants which would be a good indication of their ability to participate in carrying out their livelihood activities. However, the study provides some information on the vulnerability of malnourished adults who might be having reduced body lean muscle mass hence limiting their capabilities to engage in day to day activities due to reduction in their strength. The reduced HGS among malnourished and HIV positive adults may be an indication of their frailty and poor physical status. This could hinder the participation and engagement of PLHIV and malnourished adults in strenuous and labour intensive activities like digging, ploughing, pruning hence their inability to effectively have adequate food supplies for themselves and their family members.

5.1.8 HIV infection is associated with differences in bioelectrical impedance parameters among adult residents of refugee settlements in Western Uganda.

This cross sectional study showed that HIV positive adults had lower values of reactance, resistance, phase angle and impedance. When multivariable analysis was carried out with

participants stratified by gender, HIV infection was significantly associated with differences in phase angle, Resistance/Height, H^2/Impedance, and 1/Impedance, in both gender. Furthermore, having poor nutritional status was associated with having reduced reactance, resistance and phase angle among male and female participants for the cross sectional study.

Mean values for R/H and Xc/H were lower, in absolute terms, for HIV positive participants compared to HIV negatives. Based on the nutritional status, there were difference observed between the male and female malnourished participants. Male malnourished participants had lower values of R/H and Xc/H compared to those who had 'normal' weight – the Xc/H being statistically significant. Female malnourished participants had significantly higher R/H values and lower Xc/H which was not statistically significant compared to females with 'normal' nutritional status.

As mentioned previously, the use of raw bio impedance parameters has been suggested to counter the difficulties associated with getting comparable predictive equations for populations being studied and getting the required conditions of hydration status which may not be met especially due to body composition changes during sickness [150-153]. The most commonly used bio impedance parameters are phase angle and the combined use of reactance and resistance standardised by height in the RXc graph as well as 1/Z and H^2/Z [155,]. Previous studies have shown phase angle to be associated with severity of HIV infection, and phase angle being a prognostic marker among PLHIV [157]. In this study, when stratified by gender, HIV positive adults had significantly lower phase angle. The difference in phase angle was even more marked among those participants who were underweight. As has been observed in other studies, the lower phase angle seen among HIV positive and malnourished participants of this study could be an indication of poor health status and reduced cell integrity.

The bioelectrical impedance vector analysis (BIVA) approach developed by Piccoli et al which uses the plot of the impedance parameters resistance (R) and reactance (Xc) normalized per height as a bivariate vector in the RXc graph helps in providing a qualitative measure of soft tissue. The position and length of the vector provides information about the hydration status, body cell mass and cell integrity [39,174]. This study showed minimal difference of the R/Xc graphs for male and female participants based on their HIV status. This is possibly an indication that among the participants surveyed HIV status did not affect the hydration status and cell integrity hence the minimal differences observed. It should also be noted that more than 54% of HIV positive participants were taking ARVs at the time of participation in the study. This could have normalised their CD4 count thus preventing secondary infection. This could suggest that the severity of clinical HIV infection was minimal among quite a high proportion of the HIV positive participants that participated in the study. There were more marked and significant differences in the RXc graphs when the nutritional status of the participants was considered. This showed that malnutrition could be having a greater effect on the hydration status and cell integrity of the participants hence being in poor health status. The low phase angle seen among participants who were underweight does signify that there are drastic changes affecting the integrity of the cells. Being underweight with other co-morbidities might damage the cells and tissues of individuals hence having poor outcomes and prognosis.

Chapter 6. Results for Malnourished HIV Positive Adults in the Kyegegwa Longitudinal study

6.1 Introduction

In this chapter, I present the key findings from the longitudinal study conducted at Kyegegwa Health Centre IV. There were 74 malnourished HIV positive adults recruited into the study at different times and each of these were followed-up for a period of 16 weeks. The participants recruited were receiving nutritional supplementation with a Ready to Use Therapeutic Food (RUTF) locally known as 'RUTAFA'. All the participants received nutritional education and they were offered treatment for opportunistic infections and other diseases. At the time of recruitment into the longitudinal Kyegegwa study, there were 32 participants who were taking ARVs as part of their treatment for HIV/AIDS.

During the analysis of the results of the longitudinal study, I explored two hypotheses which are stated below along with the associated key research questions.

Hypothesis 4: The functionality of malnourished HIV positive adults, as measured by Hand Grip Strength (HGS), improves during nutritional therapy and is correlated with changes in bioelectrical impedance parameters.

The related questions for this hypothesis were:

2.1 What is the magnitude of change of HGS among malnourished HIV positive adults after 16 weeks of nutritional rehabilitation?

2.2 What is the correlation of change in HGS in relation to change in selected bioelectrical impedance parameters?

2.3 What is the correlation of change in HGS in relation to change in BMI and MUAC among malnourished HIV positive adults?

Hypothesis 5: Changes in weight or MUAC during nutritional therapy of malnourished HIV positive adults are correlated with changes in the bioelectrical impedance parameters[35].

The related questions for this hypothesis were:

1.1 What is the magnitude of change in the anthropometric and bioelectrical impedance parameters of malnourished HIV positive participants after 16 weeks of nutritional rehabilitation?

1.2 Are the changes in BMI and MUAC correlated with changes in selected bioelectrical impedance parameters?

6.2 Structure of chapter 6

I have divided this chapter into eight main sections. In section 6.3, I describe the recruitment of the participants that I followed up during the 16 weeks of nutritional rehabilitation as part of the longitudinal study. In section 6.4, I highlight the demographic, socio-economic characteristics and self-reported health status of the participants.

In section 6.5 and section 6.6, I present the results on the changes of the anthropometric indices and dietary diversity respectively. In section 6.7, I provide results of changes in household food insecurity access for the malnourished HIV positive adults. In sections 6.8, I highlight results for changes of hand grip strength while in sections 6.9 I provide results for changes in body composition as measured by bioelectrical impedance analyser in section seven. I end this chapter with section 6.10 in which I provide with a summary of results for Kyegegwa study.

[35] For this study I considered mainly the following BIA parameters; Reactance, Resistance, Phase angle, Impedance, H^2/Impedance and 1/Impedance

6.3 Recruitment of research participants for the Kyegegwa longitudinal study

From February 2012 to October 2012, I enrolled 104 participants who were eligible to take part in the study as described in section 3.5.1 of chapter 3 above.

6.3.1 Participants 'lost' during the study

First visit: A total of 15 (6 males and 9 females) participants did not turn up for the second assessment after being enrolled into the study. Three (2 males and 1 female) out of the 15 participants died and were reported to the ART clinic.

Second visit: A total of 9 recruited participants (3 male and 6 females) did not turn up for their third assessment. One male participant out of the nine died and was reported to the ART clinic.

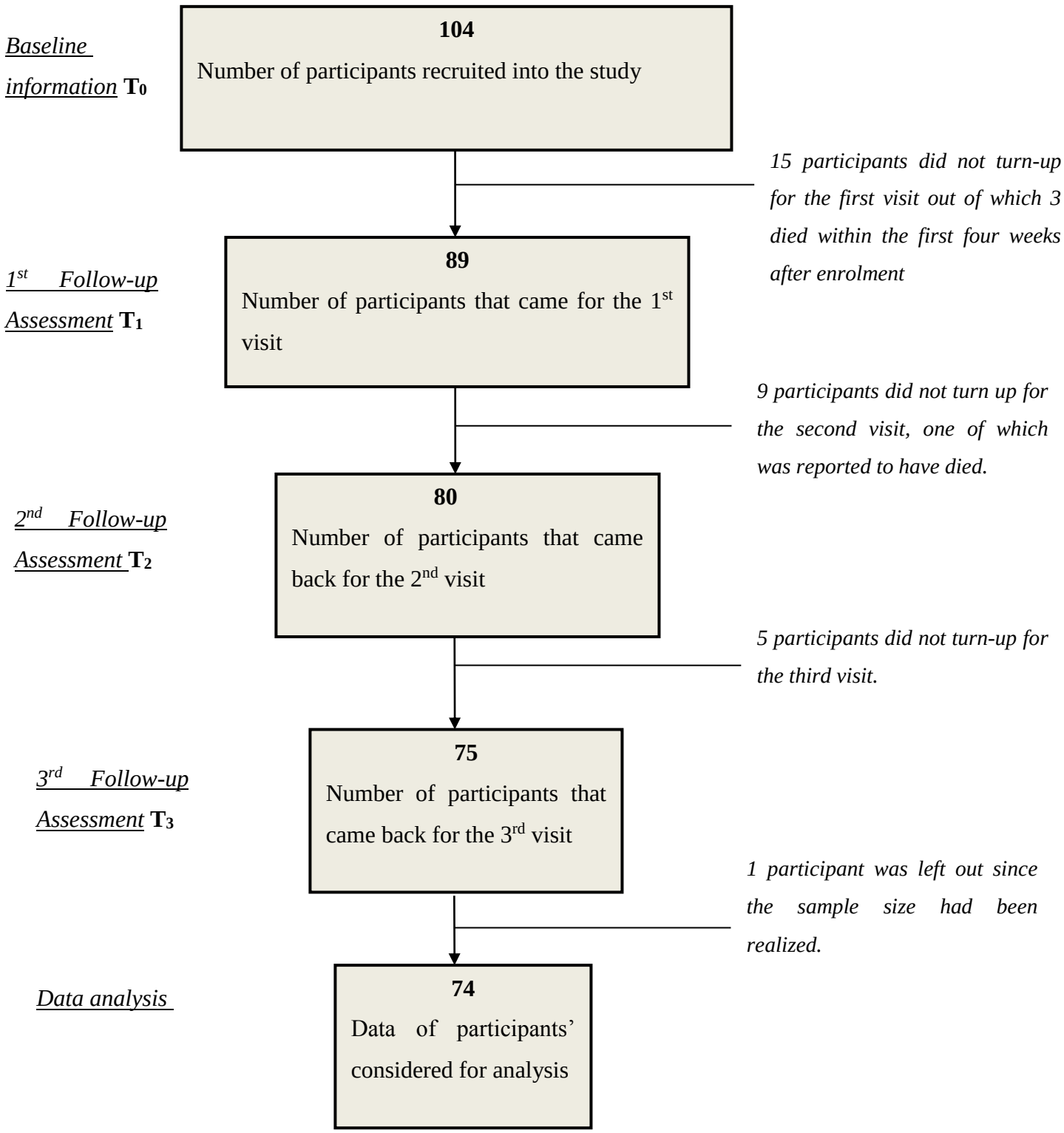
Third visit: A total of 5 participants (3 males and 2 females) did not turn for the fourth visit with their whereabouts not known.

In total, there were 75 participants who completed all the four assessments.

For analysis, I considered results for the 74 participants as per the sample size estimation that was described in section 3.5.2 in chapter 3 above.

In **Figure 6.1** below, I highlight the research participants involved in the longitudinal study.

Figure 6.1 Recruitment and enrolment of participants for the Kyegegwa longitudinal study



6.4 Demographic, socio-economic characteristics, and self-reported health status of participants of longitudinal study

6.4.1 Demographic and socio-economic characteristics of participants

There were 74 participants of whom 33 (44.6%) were males and 41 (55.4%) females. These participants were aged between 22 to 59 years with an average age of 41.1 years (SD ± 9.7) and median age of 42.5 years. The average age for the female participants was 40.9 years (SD ± 9.6) while for male participants it was 41.5 years (SD ± 10.1). The difference in age among male and female participants was not statistically significant.

For the longitudinal study, all participants were Ugandans who were accessing HIV care services from Kyegegwa HC IV at the time of the study.

In **Table 6.1** below**,** I highlight the results for demographic and socioeconomic characteristics for participants of longitudinal study. There were nearly a quarter (23.0%) of the participants who had had no formal education (never gone to any educational institution). The majority of the participants (72%) were engaged in subsistence farming while 7% were not employed. The participants had an average household size was 5.5 people with a range of 1 to 11 members.

Table 6.1 Demographic and socio-economic characteristics of participants of the Kyegegwa longitudinal study

Characteristics	Categories	Frequency	Percentage
Sex	Male	33	44.6
	Female	41	55.4
Education level	No formal education	16	21.6
	Primary level	47	63.5
	Secondary level	11	14.9
Occupation	Not employed	5	6.7
	Subsistence farmer / cattle keeper	53	71.6
	Informal and formal business	14	18.9
	Salaried employee	2	2.7
Household members	Respondent staying alone	2	2.7
	1 - 2 household members	10	13.5
	3 – 5 household members	29	39.2
	6 – 8 household members	20	27.0
	≥ 9 household members	13	17.6

6.4.2 Duration of attending HIV clinic and self-reported health status of participants of the Kyegegwa longitudinal study

6.4.2.1 Attending HIV clinic and ARV treatment

Results in **Figure 6.2** show that, nearly half (48%) of the participants had been attending the HIV clinic 6 months at the time of recruitment into the study. Furthermore, 43% of participants were taking ARVs at the time of recruitment into the study, and of these nearly half of them had been on treatment for more than one year as illustrated in **Figure 6.3** below.

Figure 6.2 Months since admission to the HIV clinic at the time of recruitment into the Kyegegwa longitudinal study

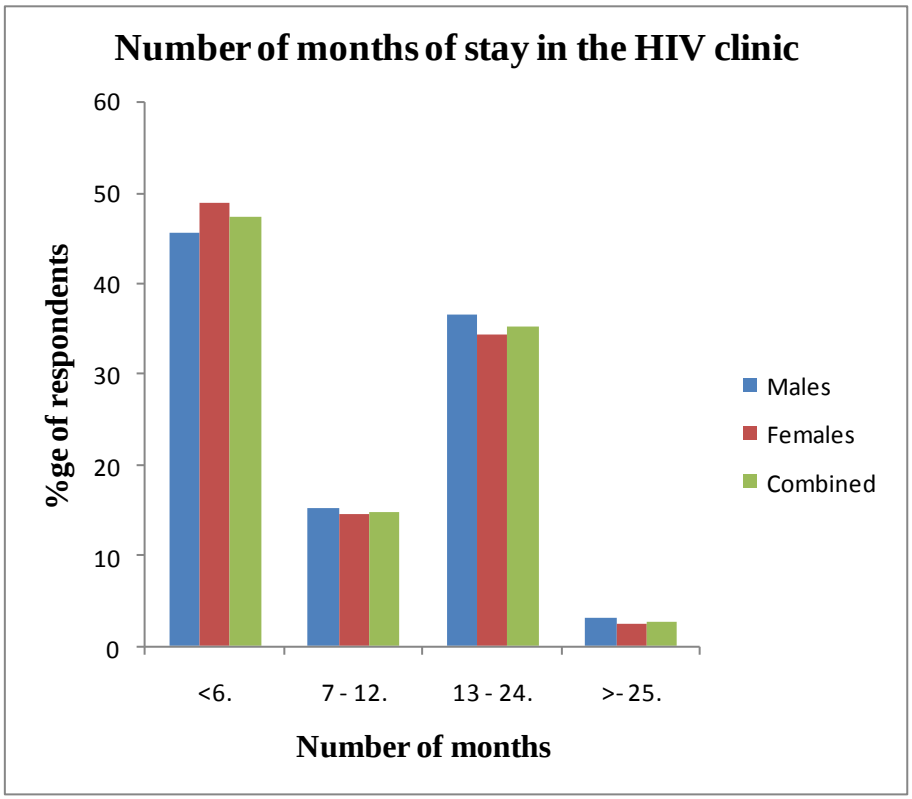
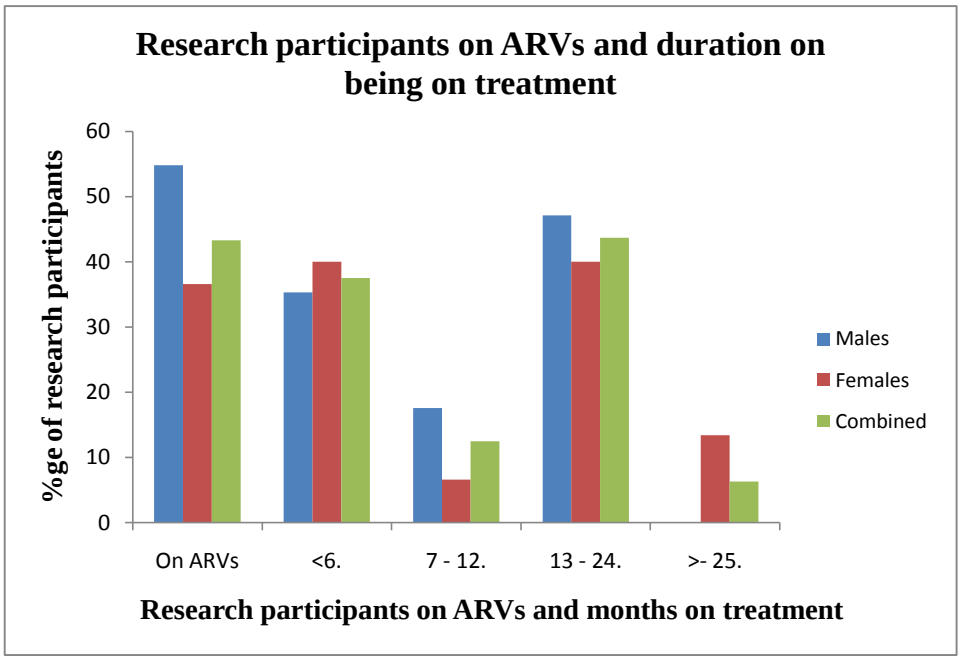


Figure 6.3 Proportion of participants taking ARVs and time spent on treatment for the Kyegegwa longitudinal study



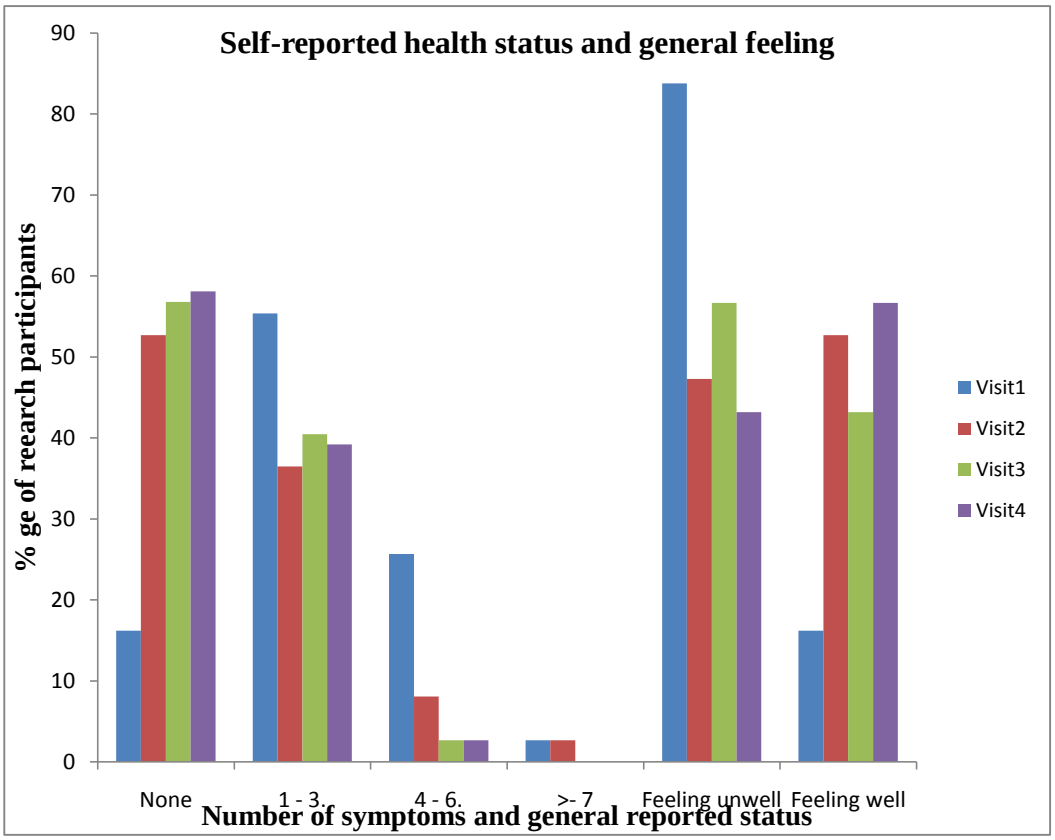
6.4.2.2 Self-reported health status of participants for the Kyegegwa longitudinal study

The commonest symptoms reported among participants of the longitudinal study were; fever, headache, oral / mouth sores, pain on swallowing, abdominal pain, vomiting, diarrhoea and generalized body itching[36].

On enrolment, nearly 84% of the research participants reported feeling unwell with 56% of them having had 1 – 3 health-related symptoms / complaints – suggestive of secondary infections due to HIV/AIDS - while more than a quarter reported having between 4 – 6 health complaints. On subsequent interviews fewer participants reported feeling unwell with 95% of those who were unwell having had 1 – 3 symptoms as illustrated in the figure below.

[36] The list of common symptoms used was based on a review done earlier from the clinic registers to find out the commonest occurring complaints / symptoms.

Figure 6.4 Proportion of self-reported health status and general physical feeling during the four visits for participants of the Kyegegwa longitudinal study



6.5 Anthropometric measurements of participants for the Kyegegwa longitudinal study

In this section, I provide results for the anthropometric measurements during the four visits. Secondly, I specifically explore the changes of some of the anthropometric measurements for the different groups of participants.

6.5.1 General anthropometric measurements

In **Table 6.2** below, I highlight the results for anthropometric indicators, Hb and HGS measurements during the four visits for the participants of longitudinal study. There was a mean weight gain of 1.63 kg; gain in MUAC was 1.2 cm, BMI was 0.21 kg/m^2, HGS was 3.0kg while there was 1.7g/dl improvement in Hb. Furthermore, 22 (30%) of the research participants were still underweight (BMI $\leq$ 18.5 kg/m^2) after 16 weeks of nutritional rehabilitation.

Table 6.2 Anthropometric and hand grip strength measurements during follow up visits in the Kyegegwa longitudinal study

Characteristics[37]	Visit 1 - Enrolment (T_0)			Visit 2 (T_1)			Visit 3 (T_2)			Visit 4 (T_3)		
	Mean	SD*	95% CI**	Mean	SD	95% CI	Mean	SD	95% CI	Mean	SD	95% CI
Weight (kg)	48.6	(5.9)	47.2 – 49.9	49.2	(6.1)	47.8 – 50.6	49.6	(6.1)	48.2 – 51.0	50.2	(6.1)	48 – 51.7
MUAC (cm)	21.8	(1.7)	21.4 – 22.3	22.1	(4.6)	21.7 – 22.7	22.1	(1.7)	22.2 – 22.9	23.0	(1.7)	22.6 – 23.4
BMI (kg/m2)	18.9	(1.9)	18.5 – 12.2	19.2	(2.0)	18.7 – 19.6	19.4	(1.9)	18.9 – 19.8	19.5	(2.1)	19.1 – 20.1
Haemoglobin (g/dl)	11.5	(1.6)	11.5 – 12.2	11.8	(1.5)	11.5 – 12.2	12.1	(1.3)	11.7 – 12.4	13.5	(1.4)	13.2 – 13.8
HGS (kg)	16.1	(5.5)	14.4 – 16.9	18.4	(7.4)	16.6 – 20.1	18.8	(6.6)	17.3 – 20.4	20.5	(18.7)	18.7 – 21.7

**SD = Standard Deviation; **CI = Confidence Interval*

[37] Mean Height was 160.1 cm ± 8.2 with 95% CI [158.2,161.9].

Figure 6.5 Mean weight during the four visits for participants in the Kyegegwa longitudinal study

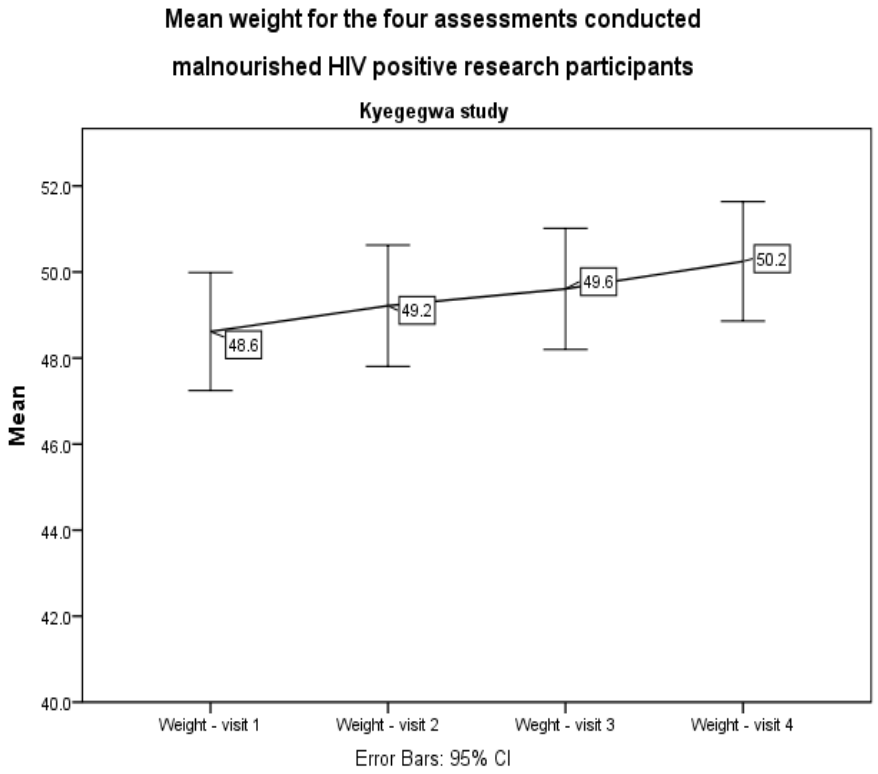
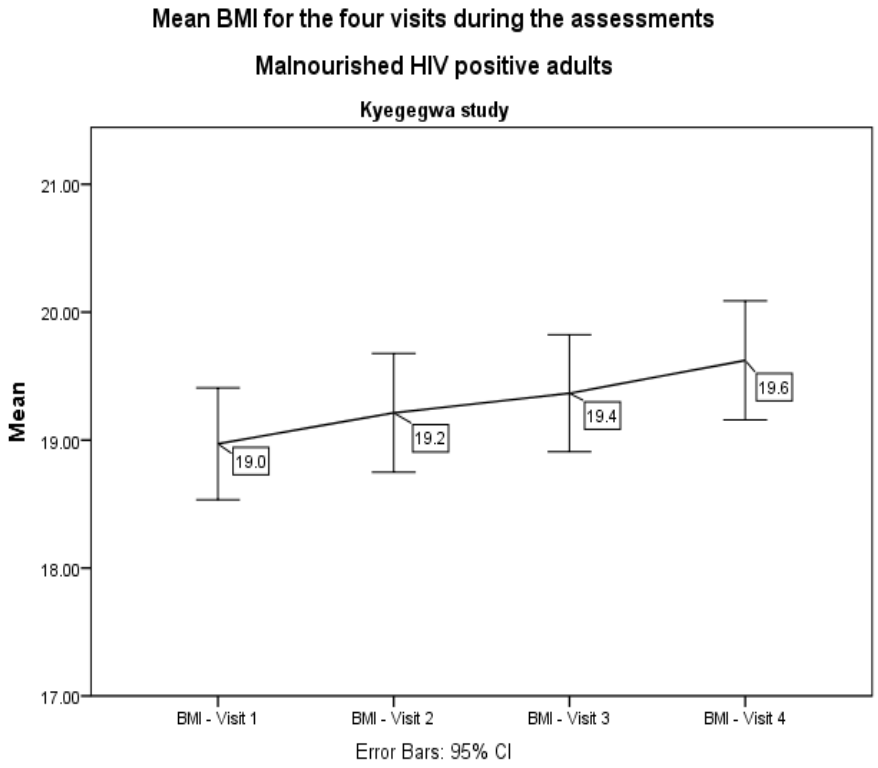


Figure 6.6 Mean BMI during the four visits for participants in the Kyegegwa longitudinal study



6.5.2 Changes in weights for different categories of participants for the Kyegegwa longitudinal study

The changes in weight for the different categories of participants are indicated in **Table 6.3** below and further illustrated in **Figure 6.7.**

The participants' average weight over the 16 weeks of study was nearly 1.63 kg and this was statistically significant ($p < 0.05$). Male participants gained more weight compared to female participants with average weight gain of 2.00 kg and 1.34 kg respectively. The changes in weight gain for male and female participants were statistically significant ($p < 0.05$).

Furthermore, the graph in **Figure 6.8** below shows that participants who were on ARVs at the time of recruitment into the study had a higher mean weight gain compared to those that were not on ARVs. However, by the fourth visit both had comparably similar weights.

Table 6.3 Change in weight by gender of participants for the Kyegegwa longitudinal study

Group	Visit4	Visit1	Change	t[38]	p-value
Total (N = 74)	50.25 ± 5.98	48.61 ± 5.93	1.63 ± 3.08	4.550	0.000
Males (N = 33)	52.76 ± 5.87	50.75 ± 2.48	2.00 ± 2.65	4.349	0.000
Females (N = 41)	48.23 ± 5.56	46.97 ± 5.46	1.34 ± 3.39	2.505	0.016

[38] Statistical test = paired samples t test.

Figure 6.7 Changes in weight during follow up visits for male and female participants in the Kyegegwa longitudinal study

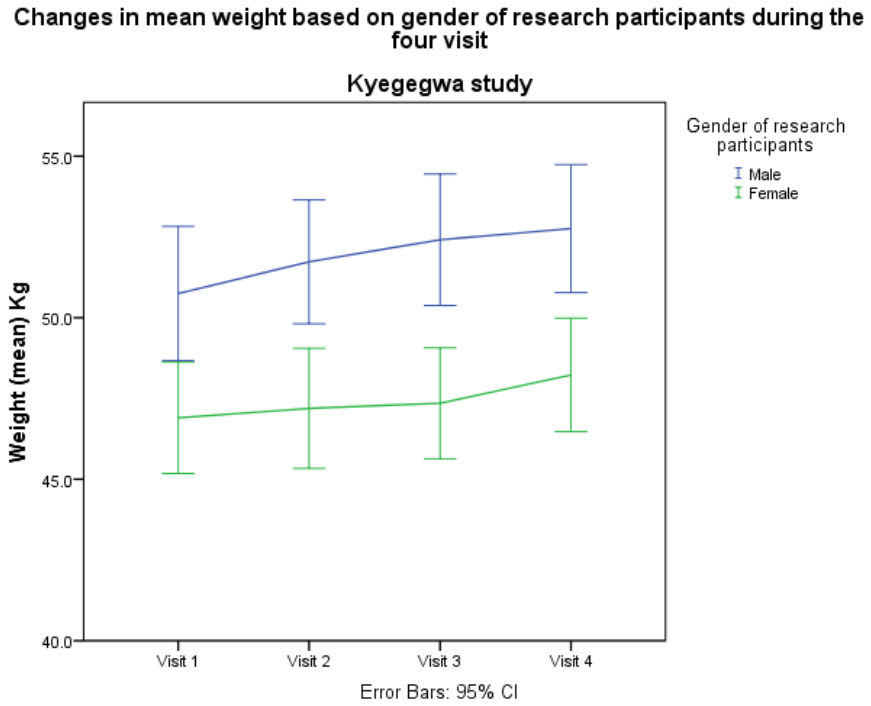
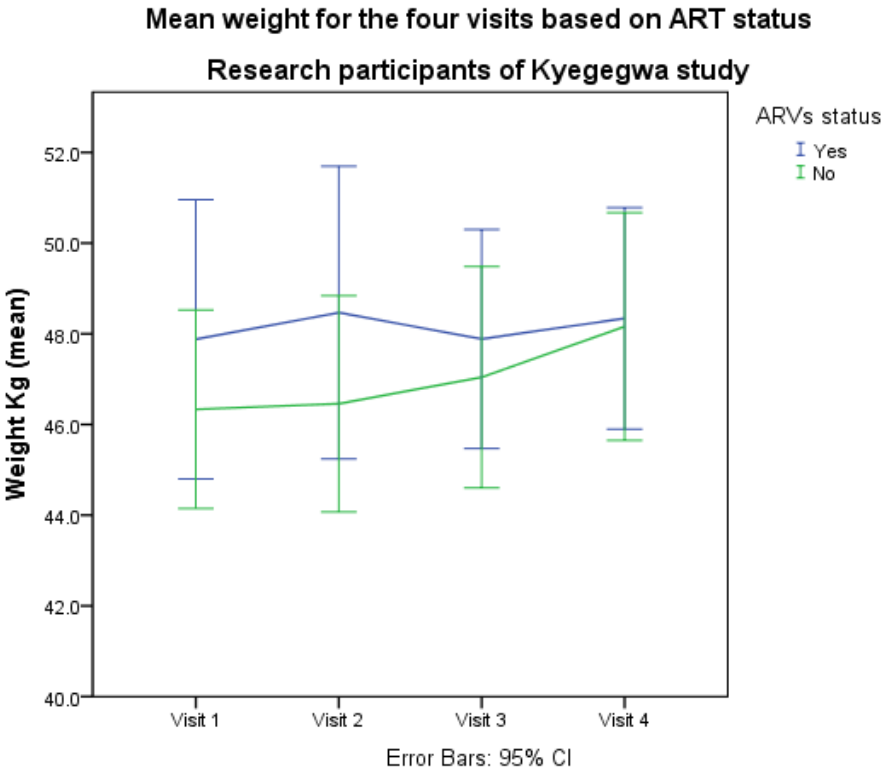


Figure 6.8 Changes in mean weight for participants based on ART status at time of recruitment into the Kyegegwa longitudinal study



6.5.3 Changes in MUAC for participants during the four visits for the Kyegegwa longitudinal study

At the time of recruitment into the study, male participants had lower average MUAC compared to the female participants. However, after the 16 weeks of follow-up, male participants had a greater increase in their average MAUC compared to female participants as illustrated in **Figure 6.9** below.

Based on the ART status, participants taking ARVs had a slightly higher mean MUAC on the three visits but by the fourth visit the MUAC was similar to that who were not on ARVs as illustrated in **Figure 6.10** below.

Figure 6.9 Mean values of MUAC for based on gender of participants during the four visits for the Kyegegwa longitudinal study

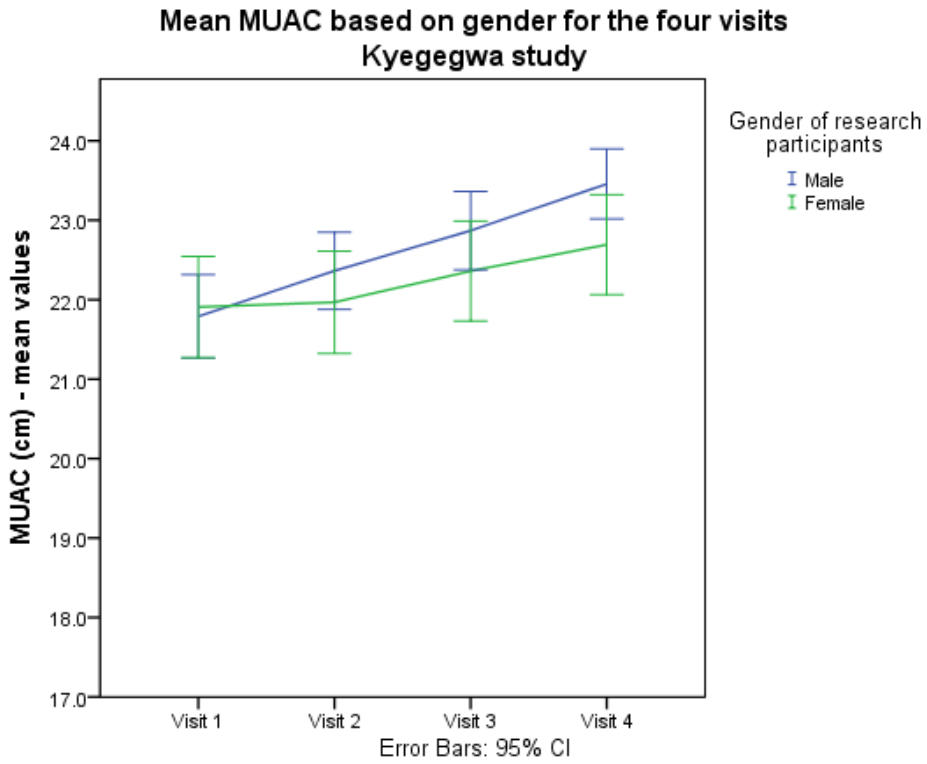
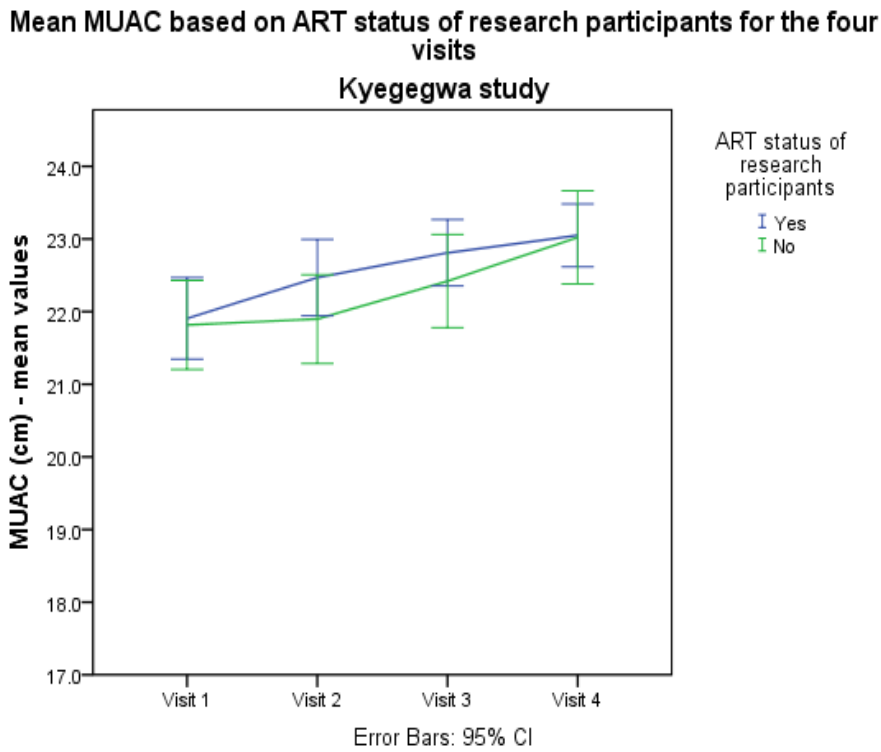


Figure 6.10 Mean values of MUAC based on ART status of participants during the four visits for the Kyegegwa longitudinal study



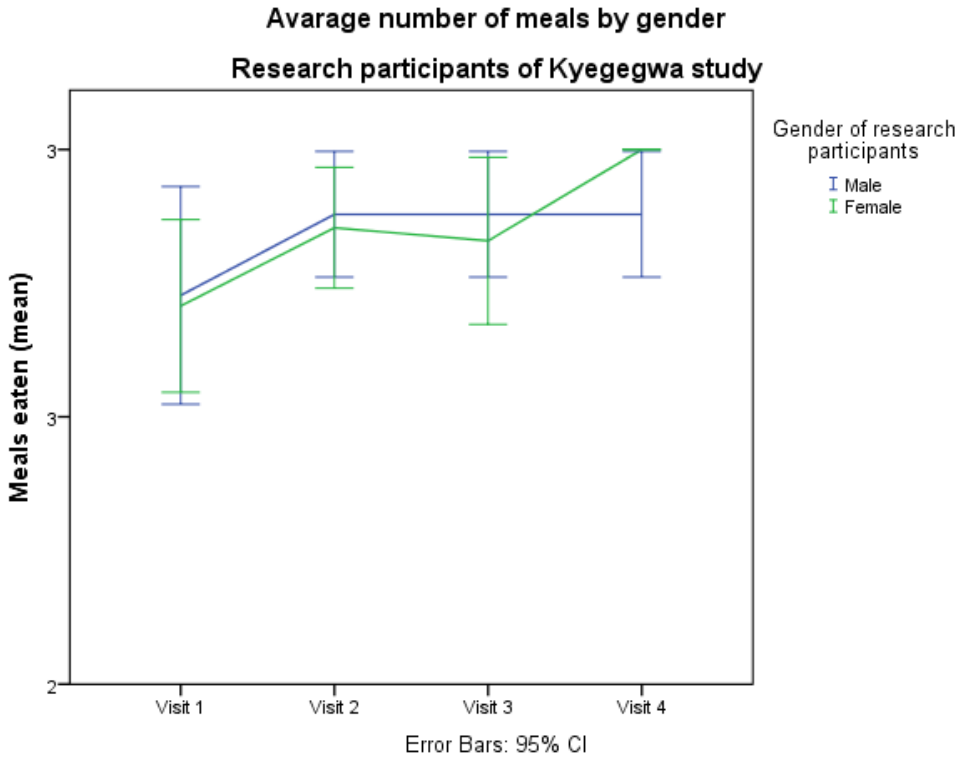
6.6 Food intake and individual dietary diversity score of participants for the Kyegegwa longitudinal study

In this section I present results relating to the foods that were eaten by the research participants 24 hours before each of the four interviews / assessments. This includes the number of meals and the different foods eaten, IDDS and dietary diversity for different groups of research participants.

6.6.1 Number of meals reported by the participants for the four visits for the Kyegegwa longitudinal study

The average number of meals eaten during the four visits was above 2.8 (SD ±0.9). There was minimal difference in the meals eaten by female and male participants.

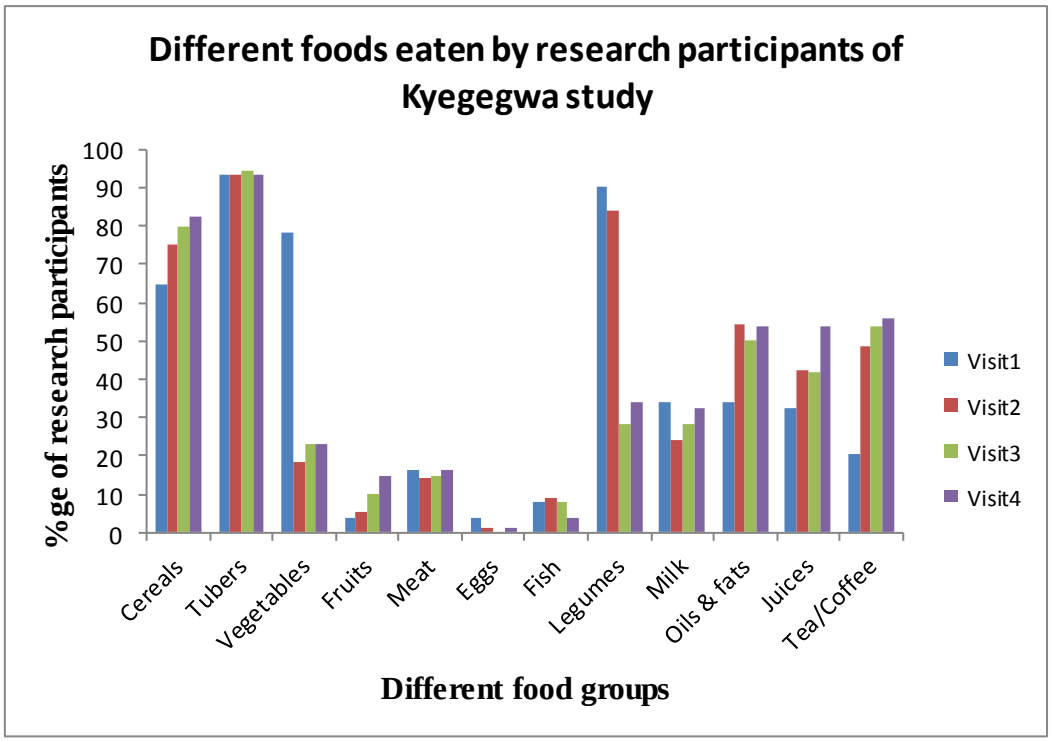
Figure 6.11Average number of meals eaten for male and female participants during the four visits for Kyegegwa longitudinal study



6.6.2 Different foods eaten by the participants reported for the four visits

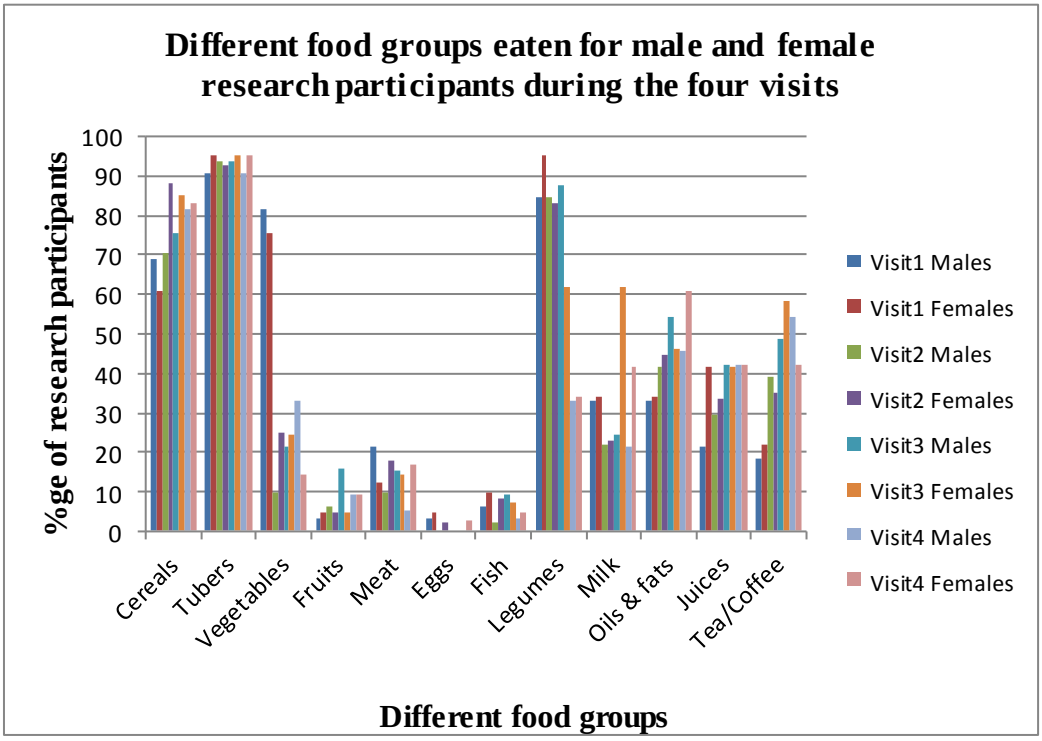
Figure 6.12 below illustrates the different types of foods eaten by the participants as reported during the fours visits. During the four visits, cereals (maize, millet, and sorghum), tubers (cassava, sweet potatoes, plantains) and legumes (beans, ground nuts, cow peas) were eaten by over 85% of the research participants of Kyegegwa study. Only a third of the participants reported drinking milk during any of the days before the interviews; 40% used cooking oils and fats for the preparation of their foods while 20% had eaten vegetables although the number was nearly 80% during the first visit. Participants rarely reported consuming eggs, fish, meat and fruits during the four visits. Apart from legumes and vegetables which many research participants had eaten during the first visit, there was similarity in the foods eaten during the four visits.

Figure 6.12 Food eaten from different food groups by participants (combined) during the four visits for Kyegegwa longitudinal study



There were minimal differences in what was eaten by males and females during the four visits as illustrated in **Figure 6.13** below.

Figure 6.13 Food eaten from the different food groups based on gender of the participants during the four visits for the Kyegegwa longitudinal study

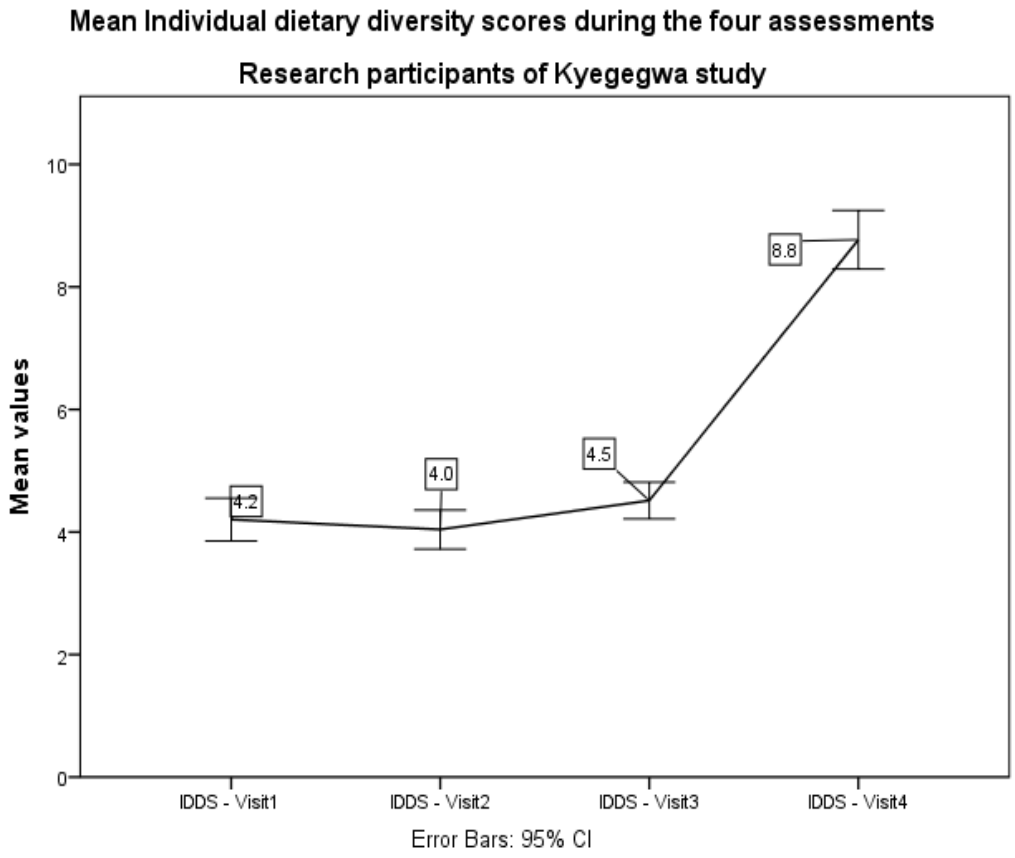


6.6.3 Individual dietary diversity scores during the four visits for participants for the Kyegegwa longitudinal study

The average IDDS scores for the first three visits was 4.2 but there was an increase in the score for the last visit which was 8.8 as illustrated in **Figure 6.14** below.

The **Figure 6.14** below shows the mean change in the IDDS for the participants during the four visits. There was an average change of over 4.5 for all groups of participants. This change was statistically significant ($p<0.05$).

Figure 6.14 Individual dietary diversity scores during the four assessments for participants of Kyegegwa longitudinal study



The trend observed in the change of IDDS was similar regardless of the participants' gender or change in the BMI over the past four visits as illustrated in **Figure 6.15** and **Figure 6.16** below.

The males had a continued improvement in their dietary diversity which picked during the fourth visit. Similarly, the dietary diversity for females dipped on the second visit but then improved during the first and third visit with similarity to that of male participants.

Figure 6.15 Individual dietary diversity scores by gender for participants of Kyegegwa longitudinal study

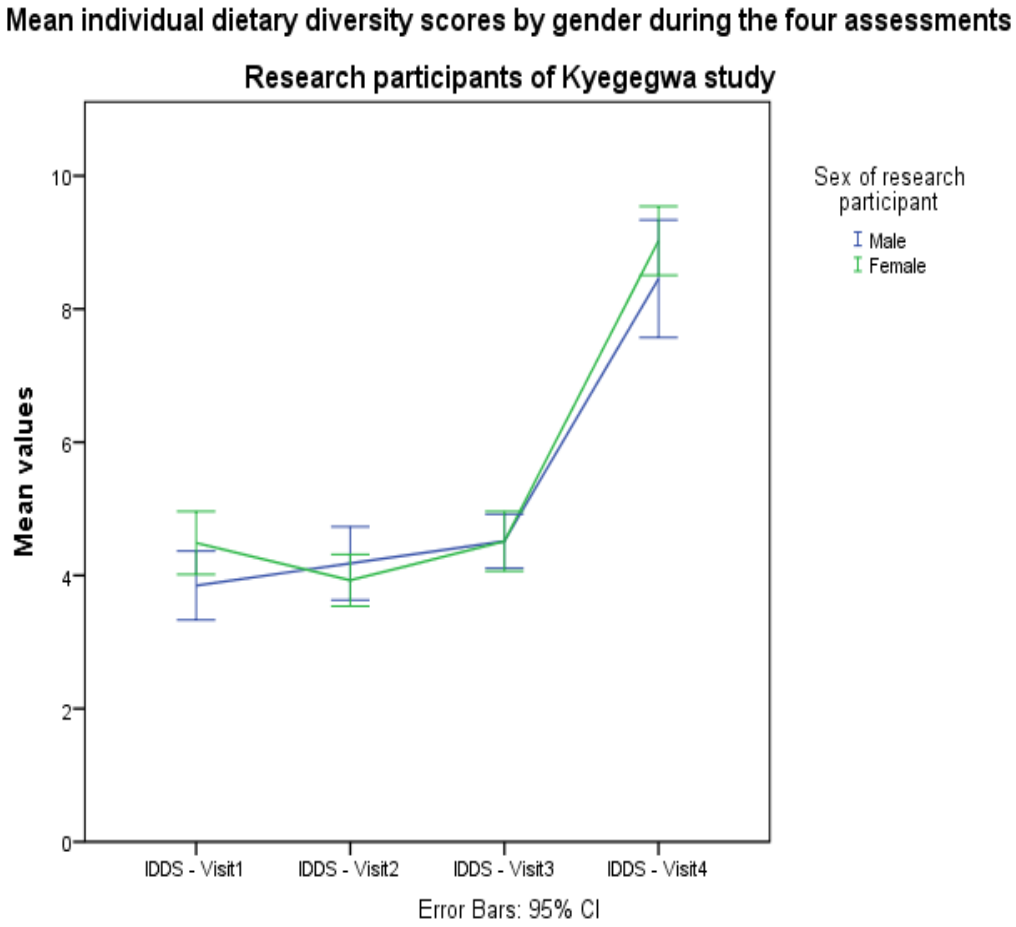
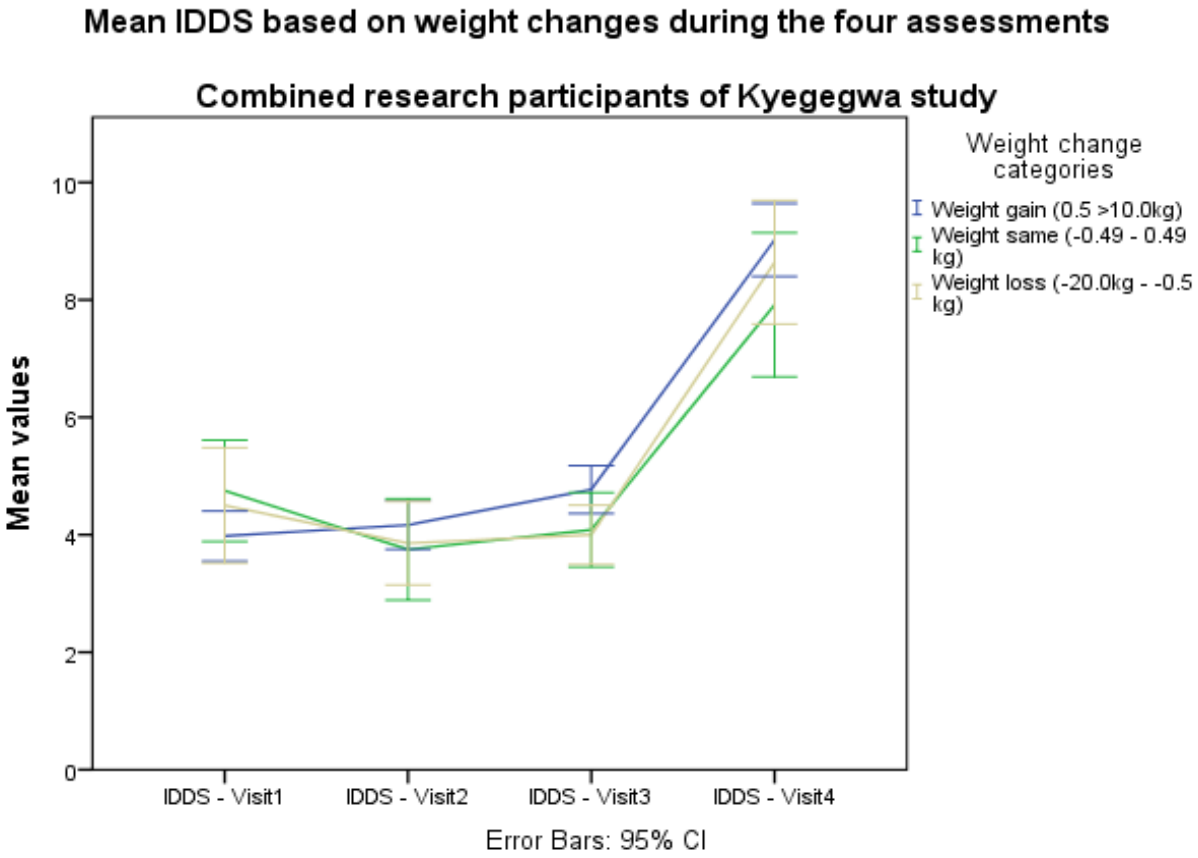


Figure 6.16 Individual dietary diversity scores based on the weight changes of the participants for Kyegegwa longitudinal study



6.7 Household food security during the four visits of participants for the Kyegegwa longitudinal study

In this section I present results relating to household food security for the participants of longitudinal study focusing on the HFIAS and HFIA prevalence. However, the results for HFIA- related conditions and the corresponding severity plus HFIA domains are put in the appendix section of this thesis.

6.7.1 Household food insecurity access scores during the four visits for the participants for the Kyegegwa longitudinal study

The HFIAS during the four visits was relatively similar with an average of 3.0 and the two last visits having higher HFIAS compared to the first two visits as illustrated in **Table 6.4** below. The trend for the HFIAS for male and female participants was similar although there

was a noticeable difference during for the HFIAS of the fourth visit (3.0 for the females compared to 2.6 for the males).

Table 6.4 Change in HFIAS scores by gender for participants for the Kyegegwa longitudinal study based on first and fouth visit

Group	Visit1	Visit4	Change	t[39]	p-value
Combined (N = 74)	3.03 ± 2.72	2.84 ± 3.79	0.189 ± 4.64	0.351	0.727
Males (N = 33)	2.55 ± 2.68	2.64 ± 3.52	-0.091 ± 4.93	-0.106	0.916
Females (N = 41)	3.41 ± 2.72	3.00 ± 4.04	0.415 ± 4.44	0.597	0.554

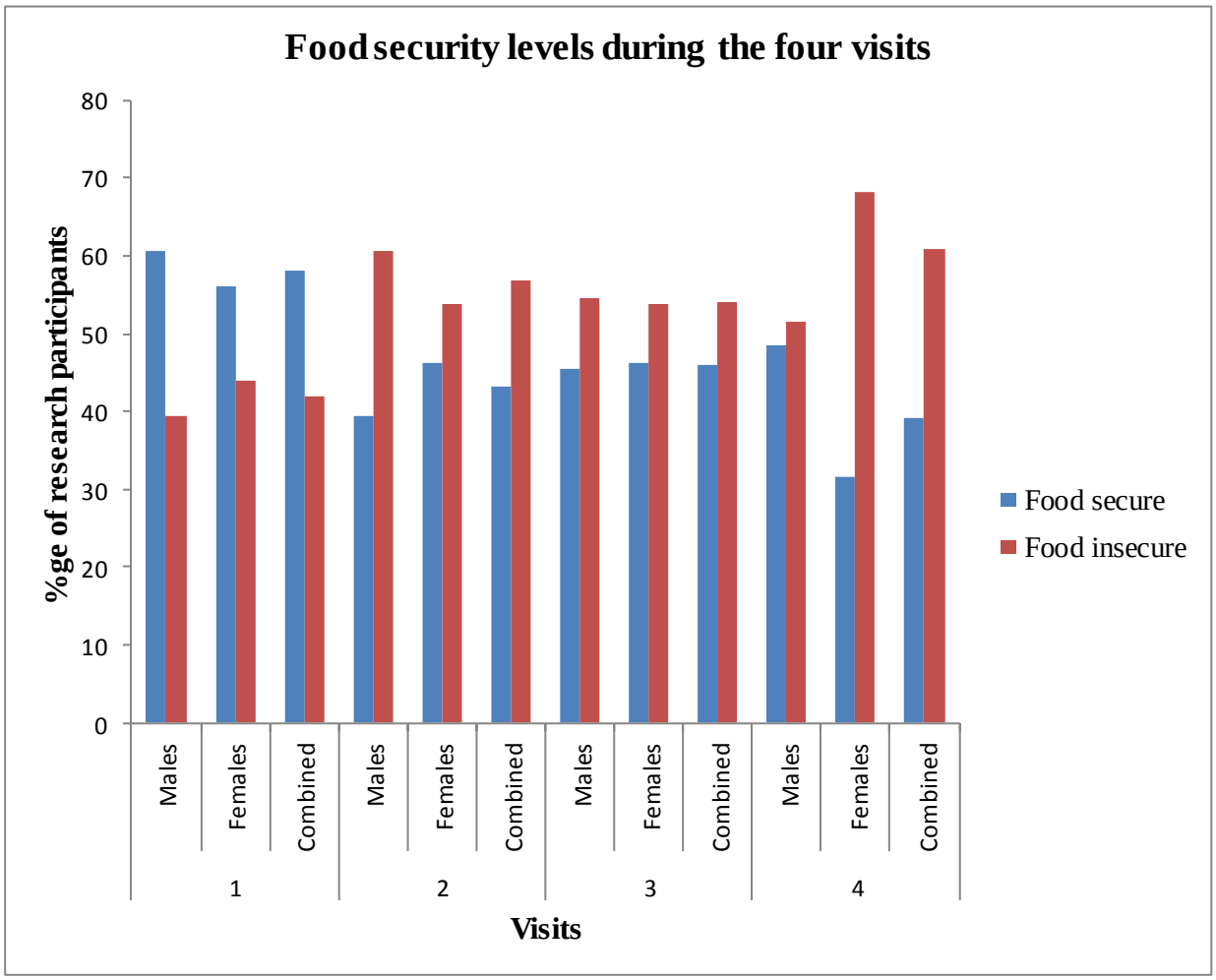
6.7.2 Household Food Insecurity Access Prevalence of participants for the Kyegegwa longitudinal study

The HFIAP categorizes the participants into two food security levels; 'food secure households' and 'food insecure households'.

During the four visits, it was observed that more participants were reporting as being food insecure. For example, 40% of participants were food insecure during visit 1 and during visit 4 it was nearly 60% of the participants. There were observed differences between males and female participants but only marked during the fourth visit. This is illustrated in **Figure 6.17** below.

[39] Statistical test = Paired t test

Figure 6.17Food security levels of participants during the four visits for the Kyegegwa longitudinal study



6.8 Changes in the hand grip strength of participants for the Kyegegwa longitudinal study

In this section I provide the results of hand grip strength for the research participants during the four assessments carried out. The HGS results are segregated by gender and for combined participants.

6.8.1 Hand grip strength changes during the four visits of participants for the Kyegegwa longitudinal study

There was an increase in HGS during the four assessments for both male and female participants but the changes in HGS based on the values for visit four and visit one were statistically significant as indicated in **Table 6.5** below.

6.8.2 Hand grip strength during the four visits

Table 6.5 Hand grip strength measurements by gender for participants during the four assessments

Group	Visits / Assessments				HGS	t^{41}	p –
	Visit1	Visit2	Visit3	Visit4	difference[40]		value
Total (N = 74)	16.1 ± 5.5	18.8 ± 7.4	19.3 ± 6.6	20.5 ± 6.2	4.4 ± 5.5	6.897	0.000
Males (N =33)	17.8 ± 6.5	22.9 ± 7.8	22.4 ± 6.6	22.9 ± 6.2	5.1 ± 6.6	4.427	0.000
Females (N = 41)	14.7 ± 4.2	15.5 ± 5.0	16.8 ± 5.4	18.5 ± 5.5	3.8 ± 4.4	5.612	0.000

There was a nearly four and half increase in the mean scores of the HGS of all the participants which was statistically significant. The males had a greater change compared to females but both changes were statistically significant.

6.8.3 Relationship of change of hand grip strength and bioelectrical impedance parameters of participants for Kyegegwa longitudinal study

I did correlation analysis between change in hand grip strength and changes in phase angle, reactance, resistance, 1 / Impedance and Height^2/Impedance stratified by gender - for male and female - participants.

[40] Difference = Mean change of HGS during fourth visit – Mean change of HGS during first visit
[41] Statistical test = paired t test

Results in **Table 6. 6** show the correlation coefficients for changes in HGS and for males and female participants. There are differences in the correlation results observed between the male and female participants.

For males; Resistance, Reactance, Resistance/Height and Reactance/Height were negatively and strongly correlated to Hand Grip Strength. The changes of HGS and Resistance and Resistance / Height were statistically significant. For female participants; changes in HGS was weakly and not significantly correlated with changes of the different BIA parameters.

There was no correlation between the changes in HGS and changes in phase angle which is the commonly used BIA parameters.

Table 6.6 Pearson's coefficients for changes of hand grip strength correlated with changes of bio impedance data for participants of Kyegegwa longitudinal study

BIA Variables (changes)	Correlation coefficient / Change in Hand Grip Strength	
	Males (N=33)	Females (N=41)
Resistance	-0.54**	-0.23
Reactance	-0.32	-0.24
Phase angle	0.07	-0.03
Impedance	0.15	0.16
Resistance / Height	-0.53**	-0.23
Reactance / Height	-0.31	-0.24
1/Impedance	-0.18	-0.25
H^2/Impedance	-0.18	-0.26

** $p<0.05$

Testing Hypothesis 4:

From the correlation results indicated in the Table 6.6 above, there is strong, negative and significant correlation of changes in HGS and resistance and resistance adjusted for height of the male participants. There was very poor and weak correlation between changes in HGS and changes in phase angle (the commonly used BIA parameter) for both male and female participants.

6.9 Body composition assessments during the four visits for participants for Kyegegwa longitudinal study

In this section I present the results of skinfold thickness and bioelectrical impedance analysis that were observed following the assessments conducted on the participants during the four visits. I also indicate the correlation between body composition and other anthropometric and nutrition indicators.

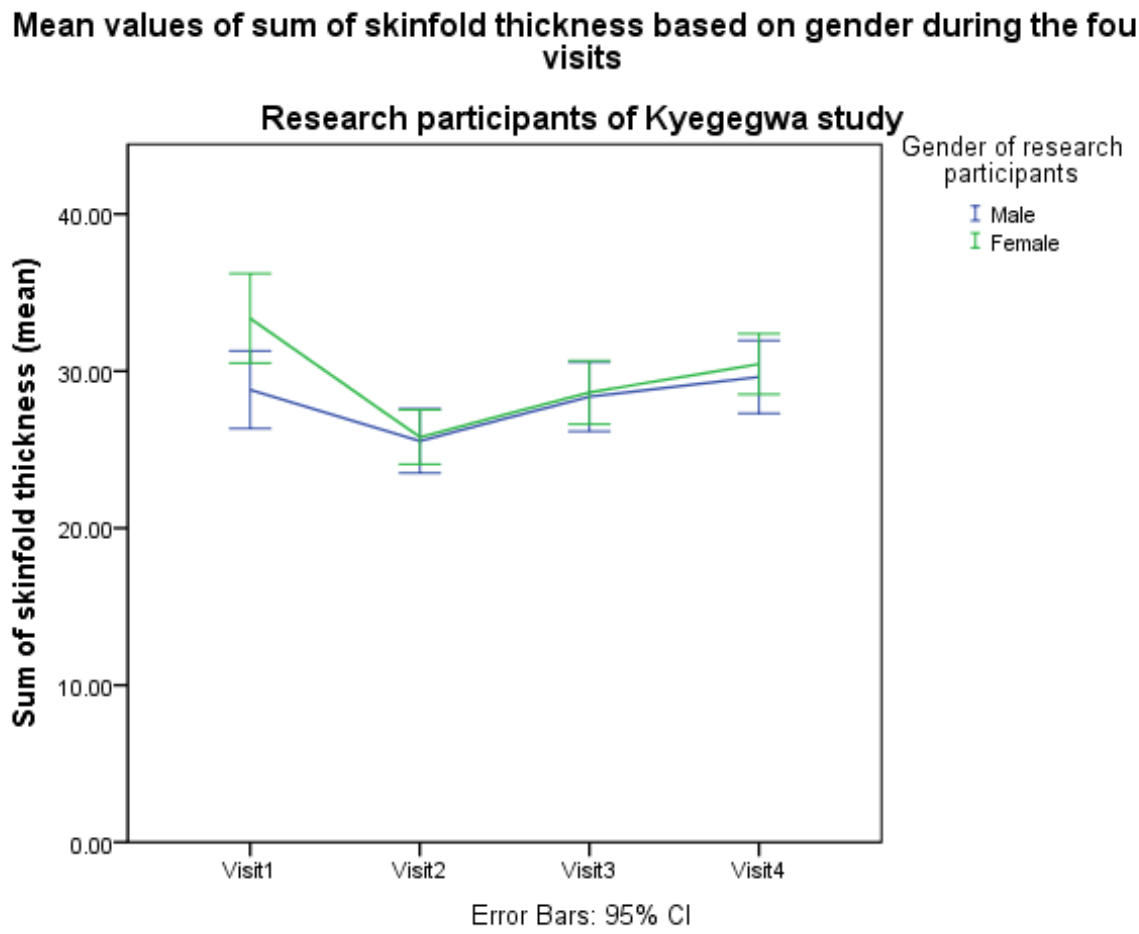
6.9.1 Skinfold thickness measurements for participants for Kyegegwa longitudinal study for the four assessments conducted

In **Table 6.7** below, the mean values of skinfold thickness for different body sites for males and females are highlighted. There was a decrease in the skinfold thickness during the second and third visits but then an increase was observed for the fourth visit. However, the increase seen during the fourth visit did not reach the same level as that of the first visit. This is illustrated in the graph in **Figure 6.18** below.

Table 6.7 Skinfold thickness measurements by gender during the four assessments for research participants for the Kyegegwa longitudinal study

Skin fold site	Visit1 / Enrolment			Visit2			Visit3			Visit4		
	Males	Females	Combined	Males	Females	Combined	Males	Females	Combined	Males	Females	Combined
Biceps	2.9 ± 0.9	3.7 ± 1.1	3.4 ± 1.1	2.9 ± 0.6	3.2 ± 0.8	3.1 ± 0.7	3.5 ± 0.7	3.6 ± 0.8	3.4 ± 1.1	3.7 ± 0.9	3.9 ± 1.1	3.8 ± 0.9
Triceps	6.2 ± 1.5	7.3 ± 2.1	6.8 ± 1.9	4.4 ± 1.1	4.1 ± 0.8	4.8 ± 1.0	5.3 ± 1.2	5.4 ± 1.3	6.8 ± 1.9	5.6 ± 1.3	5.7 ± 1.2	5.7 ± 1.3
Calf	5.3 ± 1.7	7.5 ± 2.6	6.5 ± 2.5	4.6 ± 1.2	5.5 ± 1.9	5.2 ± 1.7	5.3 ± 1.6	5.9 ± 1.9	6.5 ± 2.5	5.3 ± 1.2	6.1 ± 1.8	5.7 ± 1.7
Abdomen	6.5 ± 2.1	6.9 ± 2.6	6.8 ± 2.3	6.1 ± 2.2	5.6 ± 1.6	5.8 ± 1.9	6.6 ± 2.4	6.1 ± 1.7	6.8 ± 2.3	6.6 ± 2.3	6.4 ± 1.5	6.5 ± 1.9
Supra-scapular	7.6 ± 1.8	7.9 ± 2.2	7.7 ± 2.0	7.4 ± 1.6	7.2 ± 1.5	7.3 ± 1.5	7.6 ± 1.6	7.6 ± 1.8	7.7 ± 2.0	8.3 ± 1.7	8.4 ± 1.6	8.4 ± 1.6
Total SF	28.8 ±6.9	33.4±9.0	31.4±8.4	25.5±5.7	25.7±5.5	25.7±5.5	28.4±6.2	28.6±6.4	28.5±6.3	29.6±6.5	30.4±6.1	30.1±6.3

Figure 6.18 Sum of skinfolds based on gender of participants for Kyegegwa longitudinal study during the four visits



There was an observed decrease in the mean sum of skinfold thickness for all participants during the second visit which then gradually increased during the third and fourth visits but not reaching the level for the first visit. This was similar to both males and female research participants alike as illustrated in the Figure above.

Overall, there was a negative change (loss) in the sum of the mean skinfold thickness for all the participants. However, the males had a positive minimal change of less than 1 mm but this was not statistically significant. The change for the females was nearly 3 mm but not statistically significant. This is illustrated in the table below.

The results in **Table 6.8** below show that, unlike the females, male research participants had a positive change in their sum of skinfold thickness although in both, the changes were not statistically significant.

Table 6.8 Mean sum of skinfold thickness by gender during the 4 visits for the Kyegegwa longitudinal study

Group	Visits / Assessments*				Sum SF difference	t[42]	p – value
	Visit1	Visit2	Visit3	Visit4			
Total (N = 74)	31.4±8.4	25.7±5.5	28.5±6.3	30.1±6.3	-1.25±9.21	-1.165	0.248
Males (N =33)	28.8±6.9	25.5±5.7	28.4±6.2	29.6±6.5	0.82±8.21	0.573	0.570
Females (N = 41)	33.4±9.0	25.7±5.5	28.6±6.4	30.4±6.1	-2.91±9.72	-1.918	0.062

*All skinfold measurements in mm

6.9.2 Bioelectrical impedance analysis results during the four visits for participants of the Kyegegwa longitudinal study for the four assessments

The results of the bio impedance parameters I considered during the analysis of BIA include; Resistance (R), Reactance (Xc), Impedance (Z), Phase Angle (PA), H^2/Impedance and 1/Impedance as indicated in the **Table 6.9** below.

[42] Statistical test = paired t test

6.9.2.1 Changes in bioelectrical impedance parameters during the four visits based on gender of the participants for the Kyegegwa longitudinal study

Overall, there were changes in the mean values of bioelectrical impedance parameters for male and female participants during the four visits as indicated in **Table 6.9** and **Table 6.10** below. The changes were gradual over the four visits but these changes in majority of these bioelectrical impedance parameters during the 16 weeks of follow up of the participants, were not statistically significant as illustrated in **Table 6.11** below.

The change in Reactance was higher and statistically significant for male research participants compared to that for females; 4.73 ohms (SD = 8.86) and 1.08 ohms (SD = 8.65) respectively and in both cases the changes were statistically significant. However, the changes of phase angle that were observed were statistically significant for both male and female participants. The observed changed in phase angle during the 16 weeks of follow up was 0.53 (SD=0.85) and 0.33 (SD = 0.54) for the males and female participants. This is further illustrated in **Figure 6.19**. The degree of change of the phase angle was higher and steeper during the second and subsequent visits among the males compared to the females participants.

Based on ART status the changes observed during the four visits were similar for the two groups but slightly higher for those that were not on ARVs as illustrated in **Figure 6.20.** There were change of impedance but these changes were not statistically significant for the male and female research participants.

In **Table 6.12** and **Table 6.13**, the results indicate that there was no statistically significant difference in the bio impedance parameters for participants who were on ART and those who were not at the time of recruitment into the study, during the four visits.

Table 6.9 BIA and anthropometric parameters by gender of research participants for visit 1 and 2 for the Kyegegwa longitudinal study

Characteristic	Visit 1 (T_0)[43]			Visit 2 (T_1)		
	Males	Females	Combined	Males	Females	Combined
Cellular quality						
Reactance	55.8±9.6	61.3±9.4	55.0±8.8	57.1±9.7	61.6±10.4	59.6±10.3
Resistance	648.6±75.8	719.0±84.2	687.6±87.5	670.1±64.7	727.3±101.1	701.82±90.8
Phase angle	4.93±0.76	4.89±0.61	4.91±0.68	4.97±0.66	4.92±0.59	4.92±0.63
Illness marker	0.828±0.244	0.829±0.021	0.828±0.022	0.831±0.022	0.831±0.022	0.831±0.022
Reactance/height	33.92±6.23	39.33±6.19	36.92±6.74	34.67±6.02	39.52±6.98	37.36±6.96
Resistance/height	394.11±51.59	461.26±57.94	431.31±64.31	406.88±42.46	466.30±65.34	439.81±63.35
Nutritional status						
Weight	50.7±5.8	46.9±5.4	48.6±5.9	51.7±5.4	47.2±5.8	49.2±6.1
BMI	18.6±1.9	19.2±1.8	18.9±1.8	19.0±1.7	19.4±2.2	19.2±2.0
MUAC	21.79±1.48	21.91±2.01	21.85±1.78	22.36±1.37	21.96±2.04	22.14±1.77
Impedance	670.1±82.5	724.0±92.3	700.0±91.5	651.1±75.9	721.7±84.4	690.2±87.6
$Height^2$/Impedance	41.26±6.05	34.22±4.85	37.36±6.43	42.39±5.84	34.28±4.81	37.90±6.64
1/Impedance[44]	15.2±1.9	14.0±1.7	14.5±1.9	15.5±1.7	14.0±1.6	14.7±1.8

[43] Baseline mean values
[44] Results multiplied by 10,000.

Table 6.10 BIA and anthropometric parameters by gender of research participants for visit 3 and 4 for the Kyegegwa longitudinal study

Characteristic	Visit 3 (T_3)			Visit 4 (T_4)		
	Males	**Females**	**Combined**	**Males**	**Females**	**Combined**
Cellular quality						
Reactance	58.5±10.2	62.8±10.7	60.8±10.6	60.5±10.8	62.3±9.9	61.5±10.3
Resistance	648.6±64.6	720.8±91.3	688.6±87.8	666.7±76.0	722.8±93.6	698.7±89.8
Phase angle	5.22±0.81	5.15±0.80	5.17±0.80	5.46±0.93	5.22±0.64	5.33±0.78
Illness marker	0.825±0.301	0.829±0.029	0.827±0.030	0.826±0.041	0.828±0.022	0.827±0.032
Reactance/height	35.5±66.76	40.27±6.95	38.17±7.22	36.81±7.16	36.81±7.16	38.58±7.09
Resistance/height	393.94±43.48	462.30±60.47	431.82±63.27	406.09±49.59	463.47±60.98	437.88±62.77
Nutritional status						
Weight	52.4±5.7	47.4±5.4	49.6±6.1	52.7±5.6	48.2±5.5	50.2±5.9
BMI	19.3±1.7	19.5±2.1	19.4±1.9	19.4±1.7	19.8±2.2	19.6±2.0
MUAC	22.87±1.39	22.3±61.99	22.58±1.76	23.46±1.24	22.69±1.99	23.03±1.73
Impedance	670.0±66.7	730.3±101.2	703.4±92.0	654.6±64.5	710.5±136.9	685.6±113.5
$Height^2$/Impedance	41.01±4.84	34.02±5.13	37.14±6.07	41.99±5.17	34.13±4.70	37.64±6.27
1/Impedance	15.1±1.4	13.9±1.8	14.4±1.7	15.4±1.5	13.9±1.6	14.6±1.7

Table 6.11 Mean change by gender for Visit 4 and Visit 1 ($t_4 - t_0$) during 16 weeks follow up period and paired t tests

Characteristics	Mean change (+-SD)			Paired t test					
	Male	Female	Combined	Male		Female		Combined	
	(N = 33)	(N= 41)	(N = 74)	t	p value	t	p value	t	p value
Reactance	4.73±8.86	1.02±8.65	2.67±8.88	3.063	***0.004***	0.756	0.454	5.590	***0.012***
Resistance	20.09±83.07	3.83±74.14	11.08±78.13	1.389	0.174	0.331	0.743	1.220	0.226
Phase angle	0.53±0.85	0.33±0.54	0.42±0.69	3.552	***0.001***	3.879	***0.000***	5.590	***0.012***
Illness marker[45]	-1.6±37.5	-0.6±20.7	- 1.1±292.0	-0.246	0.807	-0.188	0.852	-0.311	0.757
Reactance/height	2.89±5.45	0.68±5.56	1.67±5.58	3.050	***0.005***	0.793	0.433	2.575	***0.012***
Resistance/height	11.98±51.23	2.21±46.40	6.57±48.52	1.344	0.188	0.306	0.762	1.165	0.248
Weight	2.00±2.65	1.33±3.39	1.63±3.08	4.349	***0.000***	2.505	***0.016***	4.550	***0.000***
MUAC	1.66±1.20	0.78±1.65	1.17±1.52	7.972	***0.000***	3.046	***0.004***	6.655	***0.000***
BMI	0.74±0.99	0.58±1.35	0.65±1.19	4.257	***0.000***	2.775	***0.008***	4.680	***0.000***
Impedance	-15.45±47.54	-13.48±104.57	-14.36±83.57	-1.868	0.071	-0.198	0.844	-1.265	0.201
Height^2/Impedance	0.725±2.997	-0.085±2.031	0.276±2.52	1.391	0.174	-0.268	0.790	0.943	0.349
1/Impedance	0.26±1.71	-0.034±0.7	0.96±0.97	1.268	0.214	-0.278	0.782	0.849	0.399
Hand gip strength	1.69±1.70	1.67±2.38	4.37±5.46	5.721	***0.000***	4.478	***0.000***	4.650	***0.000***

[45] Results multiplied by 10,000

Table 6.12 Mean values for participants for the Kyegegwa longitudinal study based on ART status during the four visits

Characteristics	Visit 1		Visit 2		Visit 3		Visit 4	
	ARVs	No ARVs	ARVs	No ARVs	ARVs	No ARVs	ARVs	No ARVs
Reactance	56.55±9.74	60.63±9.63	57.54±10.66	61.15±9.87	59.15±11.68	62.20±9.75	59.04±11.53	63.44±9.00
Resistance	664.03±79.29	705.62±90.02	677.06±76.37	720.69±97.19	668.41±79.49	704.02±91.57	674.72±81.74	717.00±92.27
Reactance/height	35.18±6.25	38.24±6.86	35.78±6.71	38.56±6.99	36.80±7.47	39.22±6.74	36.75±7.63	39.98±6.39
Resistance / height	413.89±57.26	444.58±66.85	421.63±52.75	453.65±67.73	416.63±57.26	443.38±65.81	420.16±55.54	451.38±65.20
Phase angle	4.88±0.69	4.93±0.67	4.90±0.62	4.93±0.64	5.15±0.63	5.19±0.70	5.27±0.79	5.36±0.78
Illness marker*	82.96±2.29	82.81±2.18	83.16±2.02	83.14±2.33	82.68±3.24	82.85±2.84	82.70±3.81	82.82±2.61
Weight	49.54±5.70	47.91±6.06	50.28±5.88	48.41±6.16	49.96±5.37	49.33±5.37	50.49±5.50	50.06±6.38
BMI	19.13±1.79	18.85±1.96	19.42±1.91	19.06±2.06	19.29±1.65	19.42±2.21	19.49±1.68	19.72±2.24
MUAC	21.91±1.55	21.82±1.96	22.46±1.64	2189±1.95	22.81±1.26	22.42±2.05	23.05±1.20	23.02±2.06
Impedance	675.16±87.87	718.93±90.74	666.50±79.45	708.31±90.23	677.13±78.63	723.40±97.24	675.53±79.56	707.62±90.27
H^2/Impedance	39.11±6.42	36.03±6.19	39.54±6.27	36.66±6.71	38.80±5.52	35.86±6.24	38.96±5.96	36.63±6.38
1/Impedance**	15.1±2.0	14.1±1.7	15.2±1.7	14.3±1.8	14.9±1.6	14.1±1.7	14.9±1.6	14.3±1.7
HGS	15.85±5.80	16.33±5.43	19.39±8.50	18.42±6.51	20.16±7.27	18.70±6.03	21.01±6.86	20.12±5.67
Haemoglobin	11.57±1.71	11.98±1.40	11.68±1.63	12.06±1.41	12.46±1.36	11.90±1.28	13.62±1.24	13.38±1.45

*Illness marker results multiplied by 100.

** 1/Impedance results multiplied by 10000.

Table 6.13 Mean change ($t_4 – t_0$) during 16 weeks of follow up for ARV and non-ARV participants

Characteristic	Mean change (+SD)			Two sample independent t – test		
	ARVs (n = 32)	No ARVs (n=42)	Combined (N = 74)	t	p value	95% CI
Reactance	2.49±10.46	2.81±7.59	2.67±8.88	-0.154	0.878	-4.506 – 3.859
Resistance	10.68±99.10	11.38±58.67	11.08±78.13	-0.038	0.970	-37.49 – 36.10
Reactance/Height	2.491±10.464	2.814±7.591	1.671±5.584	-0.154	0.878	-4.506 – 3.859
Resistance/Height	6.274±61.754	6.802±36.165	6.573±48.519	-0.046	0.963	-23.379 – 22.324
Phase angle	0.39±6.69	0.43±10.70	0.42±0.69	-0.206	0.837	-0.363 – 0.294
Illness marker	-0.0029±0.0299	0.0001±0.0289	- 0.0011±0.292	-0.394	0.695	-0.016 – 0.011
Weight	0.96±2.59	2.14±3.35	1.63±3.08	-1.655	0.102	-2.609 -0.242
BMI	0.37±0.99	0.86±1.31	0.65±1.19	-1.784	0.079	-1.047 – 0.582
MUAC	1.14±1.26	1.21±1.71	1.17±1.52	-0.170	0.866	-0.778 – 0.956
Impedance	-18.37±124.035	-11.30±27.94	-14.36±83.57	0.358	0.721	-46.39 – 32.26
H^2/Impedance	-0.149±3.497	0.601±1.354	0.276±0.2523	-1.272	0.207	-1.925 – 0.425
1/Impedance	-7.0±14.0	2.2±5.0	0.96±9.7	-1.299	0.198	-0.752 - 1.58
Haemoglobin	20.5±2.02	1.40±2.14	1.68±2.09	1.317	0.192	-0.331 – 1.620
Hand grip strength	5.155.17	3.78±5.65	4.37±5.46	1.066	0.290	-1.186 – 3.917

Figure 6.19 Changes in Phase Angle during the four visits for participants of Kyegegwa longitudinal study

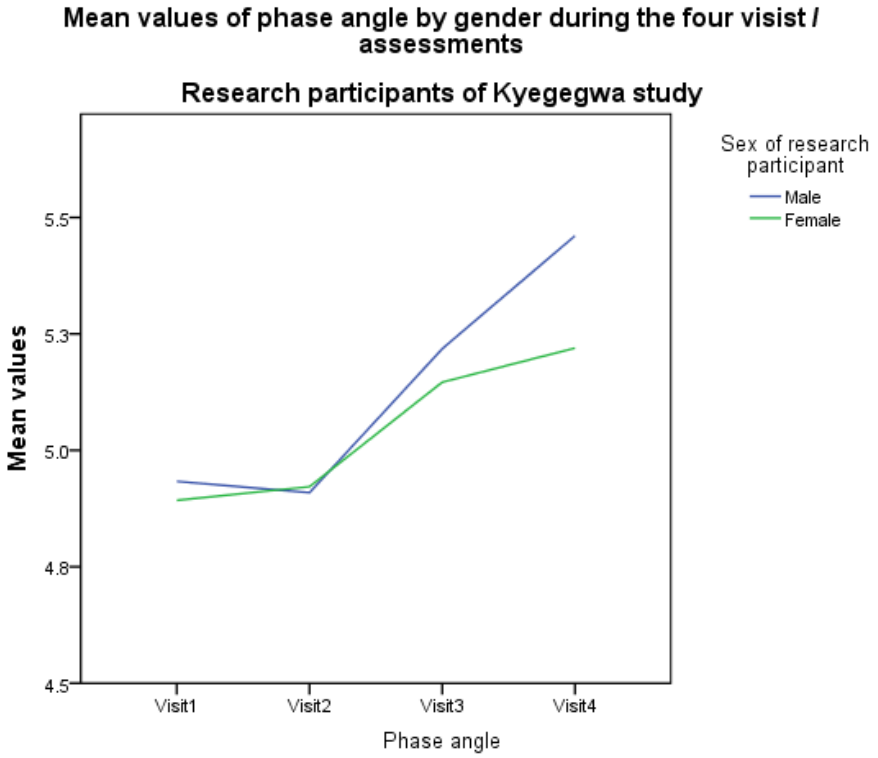
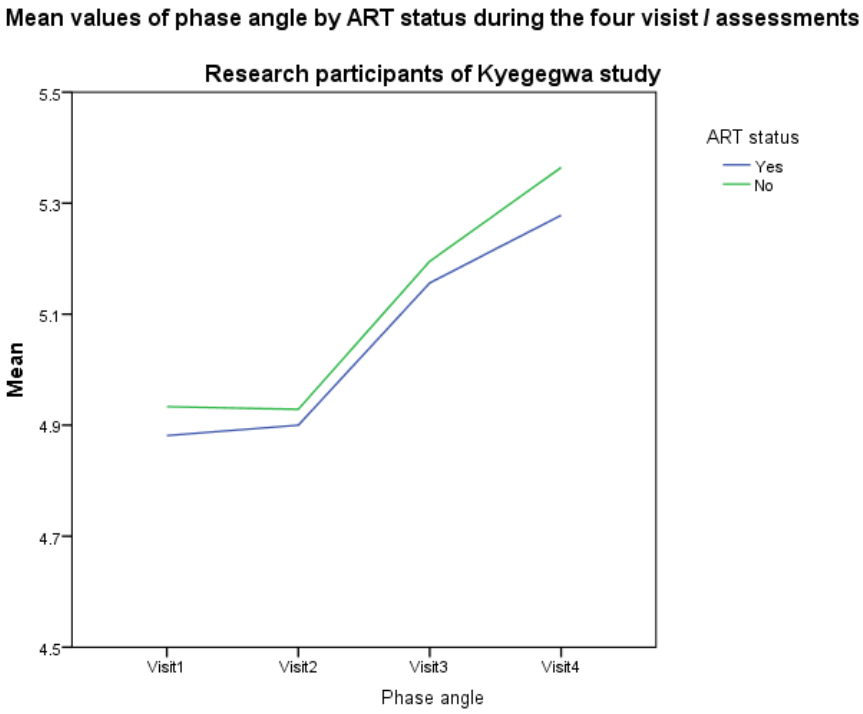


Figure 6.20 Changes in Phase Angle by ART status of participants during the four visits for the Kyegegwa longitudinal study



6.9.2.2 Bioelectrical Impedance Vector Analysis (BIVA) and R/Xc graphs for participants of Kyegegwa longitudinal study

There were positive changes in phase angle, resistance and reactance for male and female research participants as indicated in **Table 6.14** below. I used the data from **Table 6.14** below, to plot the R/Xc graph for the male and female participants indicating the changes in their resistance and reactance in the 16 weeks of follow up while in the study. The results of the graphs are indicated in **Figure 6.21** for participants stratified by gender and **Figure 6.22** for participants based on whether they were on ARVs at the time of recruitment into the study or not.

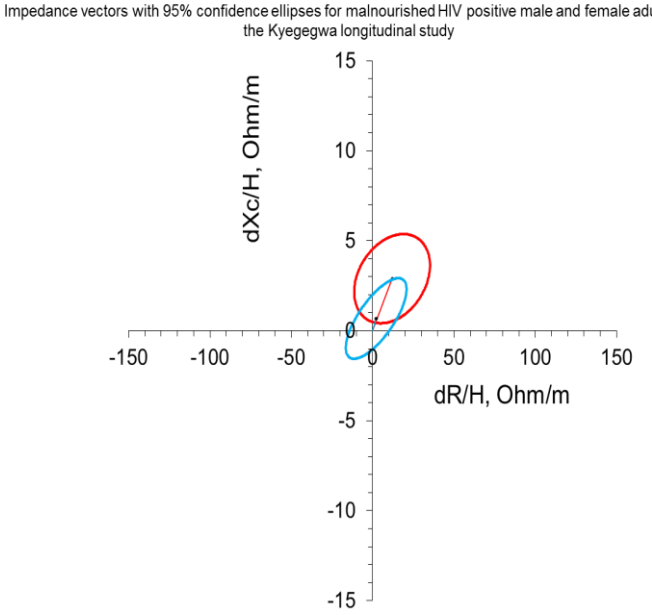
Table 6.14 Mean changes of weight, phase angle, resistance and reactance for participants of Kyegegwa longitudinal study

Category and No. of participants	dWeight[46] ±SD	dPhase angle±SD	dR/H±SD	dXc/H±SD	dcorrelation r (dR/H, dXc/H)
All participants (74)	1.63±3.08	0.42±0.69	6.6±48.5	1.7±5.6	0.54
Females only (41)	1.33±3.39	0.33±0.54	12.0±51.2	2.9±5.5	0.30
Males only (33)	2.00±2.65	0.53±0.85	2.2±46.4	0.7±5.6	0.73
On ARVs (32)[47]	0.96±2.59	0.39±6.69	6.3±61.8	2.5±10.5	0.70
Not on ARVs (42)	2.14±3.35	0.43±10.70	6.8±36.2	2.8±7.6	0.24

The impedance vector graph for male and female participants shown in **Figure 6.21** show that there were gender variations observed. Females had higher mean changes in R/H and Xc/H compared to male participants, however they had lower change in their phase angle.

[46] d = change; SD = Standard Deviation, r = Pearson's correlations coefficient
[47] On ARVs = Participants were taking ARVs at the time of recruitment into the study

Figure 6.21 Impedance vector changes with 95% confidence ellipses for male and female malnourished participants for Kyegegwa longitudinal study

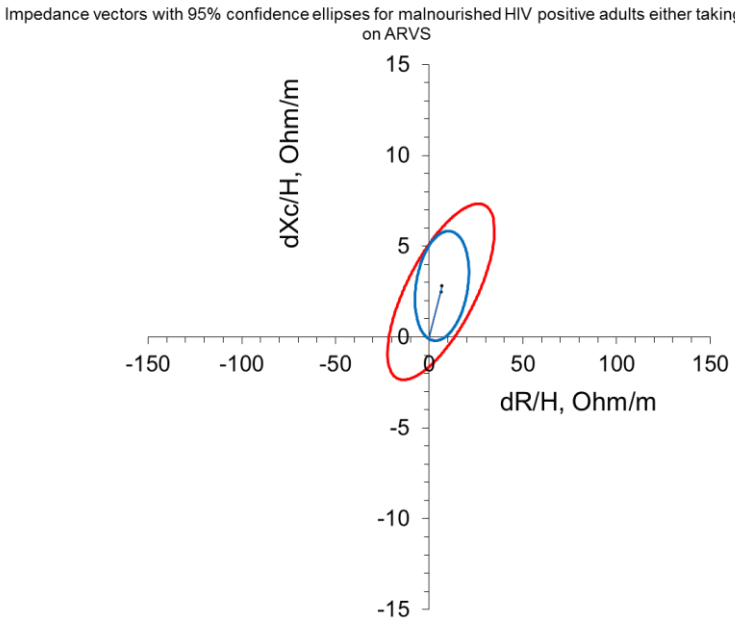


Red = Females

Blue = Males

The **Figure 6.22** below shows the impedance vector changes for patients who were on ARVs and those who were not at the beginning of the study. Overall, participants who were not on ARVs at the start of the study showed higher changes in their phase angle, R/H and Xc/H relative to those who had been on ARVs. The shift of the ellipses for those on ARVs was more towards the left.

Figure 6.22 Impedance vector changes with 95% confidence ellipses for malnourished participants on ARVs and not on ARVs for Kyegegwa longitudinal study



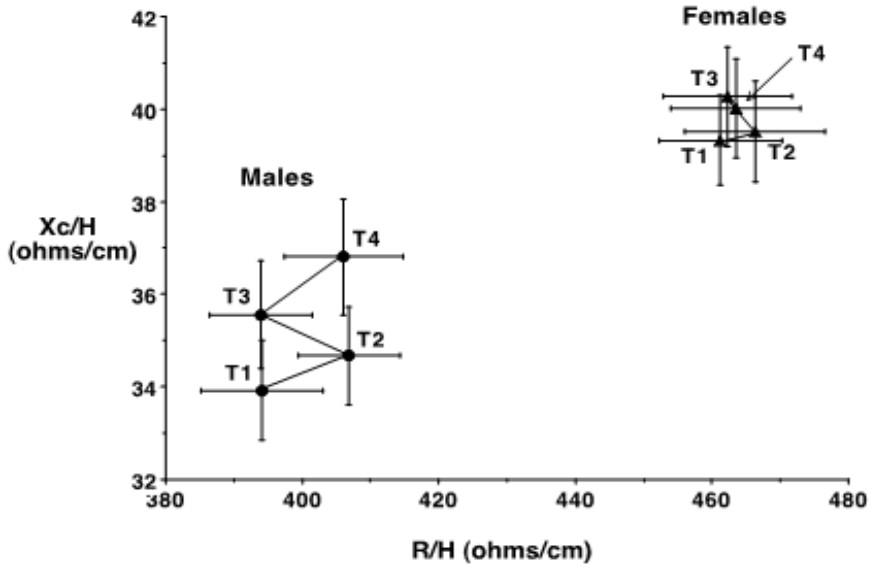
Blue = on ARVs

Red = Not on ARVs

6.9.3 Graphs showing changes in Resistance and Reactance adjusted for height during the four visits for the Kyegegwa longitudinal study

The graph in **Figure 6.23** below illustrates the changes in Reactance/Height (Xc/H) and (Resistance/Height (R/H) for male and female research participants during the four visits. The observed pattern of change was similar for male and female participants. There was an increase in Xc/H and R/H during the second visit, then an increase in Xc/H and drop in R/H and later significant increase in Xc/H and R/H for males compared to the female research participants.

Figure 6.23 Change in mean Reactance/Height and Resistance/Height for male and female participants of Kyegegwa longitudinal study

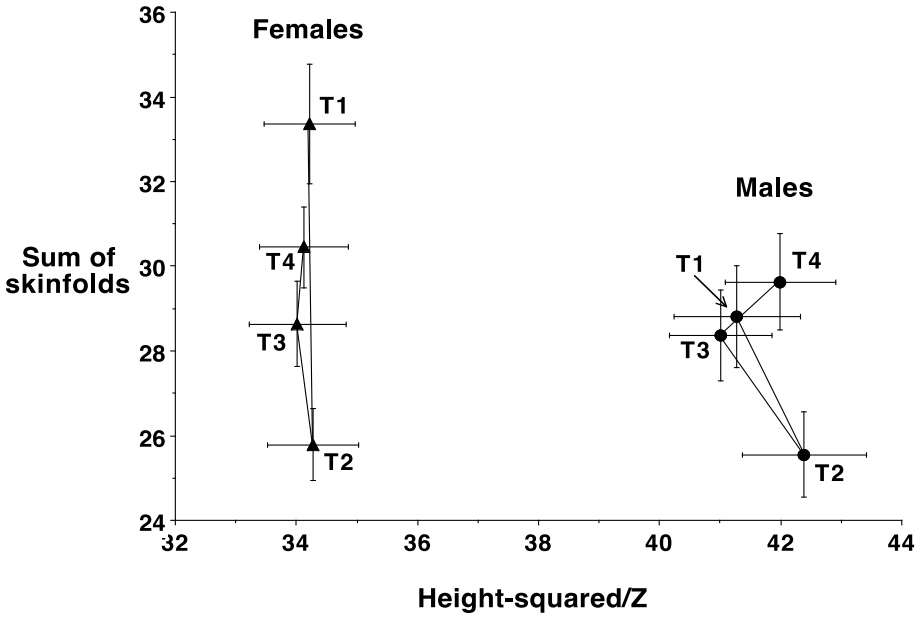


6.9.4 Graph showing changes in sum of skinfolds with Height^2/Impedance of participants during the four visit of the Kyegegwa longitudinal study

The graph in **Figure 6.24** indicates that there were different patterns in the changes in mean sum of skinfold thickness in relation to H^2/Impedance. For the females, there is a decrease in their skinfold thickness during the second visit but this decrease is reversed in the third and fourth visit although the sum of skinfold thickness do not reach levels similar to that for visit 1. For males, there was a similar

pattern but by the fourth visit there was increase in the sum of skinfold thickness and H^2/Impedance although this was not statistically significant in relation to values for visit 1.

Figure 6.24 Change of mean sum of skinfold thickness and H^2/Impedance based on gender of participants during the four visits of Kyegegwa longitudinal study



6.9.5 Graphs showing changes in the Resistance and Reactance adjusted for height of malnourished HIV positives adults compared with BIA parameters for HIV negative adults based on gender

The graphs in **Figure 6.25** and **Figure 6.26,** show the changes in mean Xc/H and R/H for malnourished male and female participants when compared with values for HIV negative males and females respectively from the cross sectional study.

In both graphs, the malnourished HIV positives adults have Xc/H and R/H values which are below most of those for HIV negative adults throughout the 16 weeks of being in the nutritional rehabilitation clinic. The changes realized in the bioelectrical impedance values during the 16 weeks are fairly minimal when compared to the HIV negative participants as illustrated in the figures below.

However, there is gradual increase in mean values of reactance and resistance adjusted for height during the four visit.

Figure 6.25 Change of mean Reactance and Resistance adjusted for height for male malnourished HIV positive participants in the longitudinal study when compared with HIV negative male participants

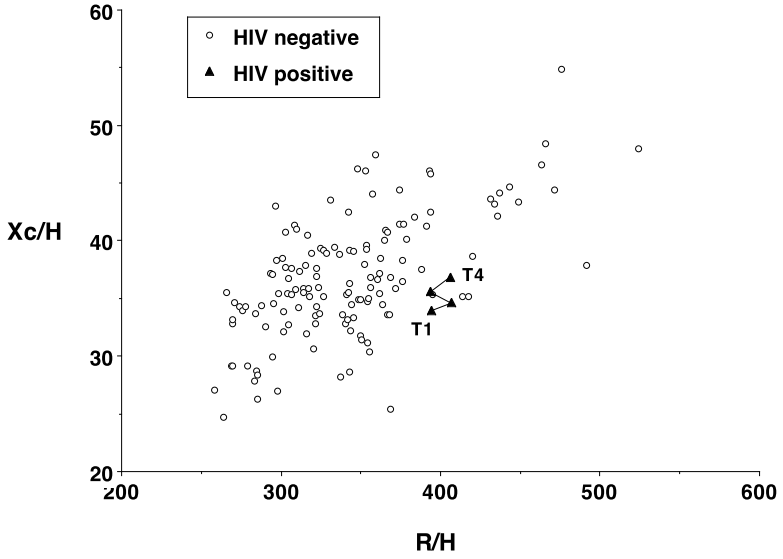
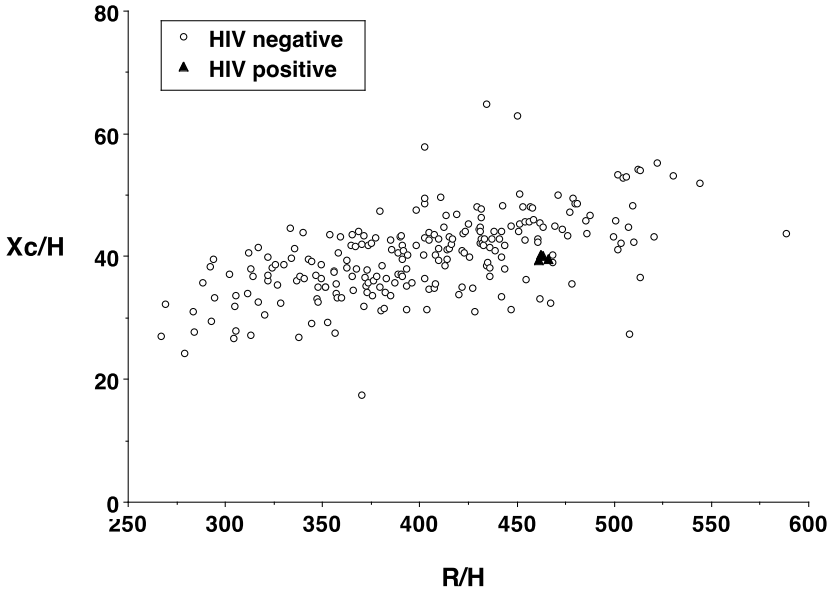


Figure 6.26Change of mean Reactance and Resistance adjusted for height for female malnourished HIV positive participants from longitudinal study when compared with HIV negative female participants



6.9.6 Graphs showing changes in sum of skinfold thickness and Height^2/Impedance for participants of longitudinal study compared to HIV negative participants

In **Figure 6.27** and **Figure 6.28**, the changes observed in mean sum of skinfold thickness after 16 weeks of follow-up were minimal compared to the sum of skinfold thickness of HIV negatives adults.

Figure 6.27 Change of mean sum of skinfold thickness and H2 / Impedance for male HIV positive participants of longitudinal study compared to HIV negative participants

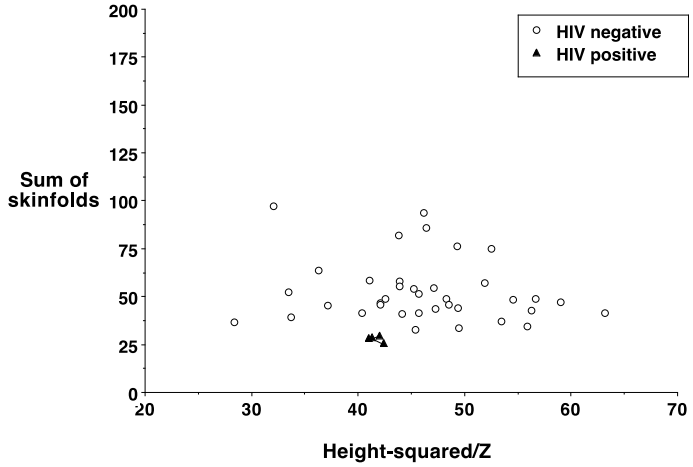
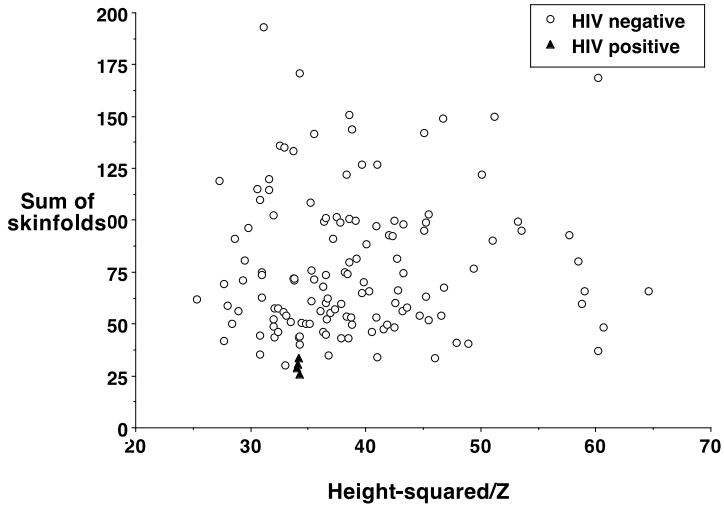


Figure 6.28 Change of mean sum of skinfold thickness and H^2 / Z for female HIV positive malnourished participants of the longitudinal study compared to HIV negative participants



6.10 Correlation analysis for change in weight, MUAC and selected bioelectrical impedance parameters for malnourished HIV positive adults for the Kyegegwa longitudinal study

The results in **Table 6.15** show the values of Pearson's correlation coefficients after testing the correlation between changes in MUAC and Weight with the different bio impedance parameters for males and female participants.

For both male and female participants, the correlations observed between changes in MUAC or Weight were all weak and not statistically significant.

Table 6.15 Pearson's correlation coefficients for changes in MUAC and Weight for the selected bio impedance data for participants of Kyegegwa longitudinal study

BIA Variables	Correlation coefficients / change of MUAC or Weight			
	Male (N=33)		Female (N=41)	
	Change of MUAC	Change of Weight	Change of MUAC	Change of Weight
Resistance	-0.22	-0.39	-0.19	-0.35
Reactance	-0.24	0.01	-0.02	-0.08
Phase angle	-0.13	0.18	0.13	-0.09
Impedance	-0.13	0.07	0.05	0.15
Resistance / Height	-0.21	-0.39	-0.18	-0.08
Reactance / Height	-0.12	0.01	-0.02	-0.34
1/Impedance	-0.08	-0.27	0.08	0.07
H^2/Impedance	-0.09	-0.08	0.08	0.07

*Changes for the BIA variables considered

** $p<0.05$

Testing Hypothesis 5:

The correlations between changes in MUAC or Weight and bioelectrical impedance parameters were weak and not statistically significant for both male and female participants.

6.11 Summary of the results for the Kyegegwa longitudinal study

6.11.1 General demographic, socioeconomic and self-reported health results of malnourished HIV positive research participants

There were 74 research participants; 31 males and 43 females. The mean age of the participants was 40.9 years (SD = 9.6) and 41.5 years (SD = 10.1) for males and females malnourished HIV positive adults respectively.

On the first visit (time of recruitment into the study), 84% of the research participants were feeling unwell and had various health complaints with the commonest being: fever, headaches, generalized body weakness and pains, poor appetite, oral sores, diarrhoea and abdominal pains among other complaints. However, after admission into the study, the number of the reported health complaints decreased during the fourth visit to only about half compared to what was reported at the recruitment into the study. Similarly, the number of participants reporting having experienced 'no symptoms' or with only '1 – 3 symptoms' increased from about 20% during the first visit to 60% during the fourth visit.

6.11.2 Changes in anthropometric measurements of the malnourished HIV positive participants

Combined, participants gained 1.63 kg during the 16 weeks period of nutritional rehabilitation. It was observed that males participants gained more weight compared to female participants - 2.00kg and 1.34kg respectively; in both cases difference in weight gained compared to the weight at the time of recruitment into the study was statistically significant ($p<0.05$).

For MUAC the gain recorded was 1.6 cm and 0.78cm for males and female participants respectively and this gain recorded was statistically significant for the two groups. It was observed that there was an overall negative gain for the body mass index among females participants of -0.17 kg/m^2. In

comparison male participants gained a mean body mass index of 0.67 kg/m^2 during the 16 weeks period of nutrition rehabilitation.

Based on ART status (whether the participants was on ARVs or not at the time of recruitment into the study), there was no difference in the change in MUAC; however, there were noticeable BMI change of 0.77 kg/m^2 compared to the negative BMI change of -0.22 kg/m^2 for participants who were not receiving ARVs at the time of recruitment into the study.

6.11.3 Food intake and individual dietary diversity scores for malnourished HIV positive participants

The average number of meals eaten 24 hours before the interview for the four visits was 2.8 with no gender differences between male and female participants. Cereals, tubers and legumes were the commonly eaten food stuffs reported during the four interviews conducted during the 16 weeks of follow up. Less than 10% of research participants ate fruits, vegetables and animal proteins indicating a higher dependency on cereals mainly maize and sorghum and pulses which mainly consisted of beans, peas and ground nuts.

The average IDDS during the 16 weeks of follow up for malnourished HIV positive participants was 4.5 with no significant gender differences observed. The was a positive trend in the dietary diversity observed among all participants irrespective of whether they had gained or lost weight, or if their weight had remained the same during the 16 weeks of follow up.

6.11.4 Household food insecurity access for the malnourished HIV positive research participants

The observed average HFIAS score was 3.0 during the four interviews conducted. There was minimal change in the HFIAS score during the 16 weeks of follow up with males having had a slight decrease in their score of -0.1 compared to a 0.2 increase for female participants.

At the first visit, 56% of participants were categorised as food secure but there was a decrease in food security for the participants during the fourth visit, with slightly less than 40% being categorized as

food secure. Only about 50% and 30% of the male and female participants were categorized as food secure during their fourth visit.

6.11.5 Hand grip strength for malnourished HIV positive research participants

There was a statistically significant increase in the hand grip strength of research participants during the four visits. The positive trend observed in the HGS showed that males had a higher increase of an average score of over 5 kg compared to that of females which was slightly less than 4.0 kg.

There was negative, strong and statistically significant correlation between the change in HGS with change in resistance and resistance/height for male participants. Change in phase angle was weakly correlated with change in HGS for both male and female participants.

6.11.6 Changes of skinfold thickness of malnourished HIV positive participants for the Kyegegwa longitudinal study

Skinfold thickness changes among malnourished HIV positive participants

There was a decrease in the sum of skinfold thickness for all the combined participants during the 16 weeks of follow up in the study. There were gradual changes in the mean sum of skinfold thickness for malnourished HIV positive adults during the four visits. Although there was similarity in the pattern of change of the sum of skinfold thickness, males had a slight increase in their mean sum of skinfold thickness while the females had a slight decrease. However, the difference in the changes observed were not statistically significant for both male and female participants.

When comparison was made for the sum of skinfold thickness for malnourished HIV positive adults with the HIV negative adults, changes were lower for the malnourished HIV positive adults. similarly

6.11.7 Bioelectrical impedance analysis changes among malnourished HIV positive participants

There were observed changes in the mean values of the bio electrical impedance parameters during the 16 weeks of nutritional rehabilitation for both males and female participants. However, there were variations in the changes based on the gender of the participants.

The change in reactance was statistically significant for the male participants as opposed to the female participants. The change in phase angle was statistically significant for both male and female research participants. However, the change for males was higher (0.53 degrees) compared to that for females (0.33 degrees).

When participants were compared based on their ART status (either taking ARVs or not at the time of recruitment into the study), there were differences in the changes in bioelectrical impedance parameters of the two groups. However, in both cases the changes that were observed were not statistically significant. For phase angle, the participants who were not on ARVs at the time of recruitment were observed to have higher mean phase angle compared to those that were on ARVs at the time of joining the study.

6.11.8 Correlation between changes of weight, MUAC and bioelectrical impedance parameters

Correlation between the change in Weight, MUAC and bioelectrical impedance parameters was done for the participants stratified by gender. For all the BIA parameters, all the correlations were weak and not statistically significant.

Chapter 7. Discussion of the results for the Kyegegwa longitudinal study

7.1 Introduction

In this chapter I present the discussion of the results from the Kyegegwa longitudinal study conducted in the Southwestern part of Uganda. In the section 7.2, I provide the discussion about the changes in weight of malnourished HIV positive adults during the 16 weeks of nutrition rehabilitation. In section 7.3, I focus on the changes in the dietary practices and household food insecurity of the participants of the longitudinal study based on the IDDS and HFIAS results.

Section 7.4 focuses on the changes in hand grip strength for both male and female participants while section 7.5 and section 7.6 focus on skinfold thickness and bioelectrical impedance analysis as measures for the body composition of the participants of Kyegegwa longitudinal study.

7.2 Change in weight of malnourished HIV positive adults undergoing nutritional rehabilitation over a period of 16 weeks

Overall, participants gained an average weight of 1.6kg of the 16 weeks of nutrition rehabilitation. This study showed that there were gender differences in the weight gained during the 16 weeks of nutritional rehabilitation of malnourished HIV positive adults. Male participants gained more weight compared to the female participants (2.0kg and 1.34kg respectively) although in both cases the weight gain over the 16 week period when compared to their initial mean weights at the start of the study, was statistically significant.

Secondly, it was observed that being on ARVs at the time of starting nutritional rehabilitation enhanced weight gain for the malnourished HIV positive adults compared to not being on ARVs specifically within the first 4 weeks of admission in the nutrition rehabilitation programme. However, after 16 weeks of stay in the nutritional programme, the weight gain for both those on ARVs and those who were not on ARVs was similar. Presumably the increase in weight could be the result of

several factors – attending a clinic for assessment of the need for ARVs, receiving treatment for secondary infections and the impact of the food supplements.

The average weight gained by the participants of Kyegegwa longitudinal study was 2.0kg (SD±3.1) over the 16 weeks of follow-up with gender differences observed. Weight gain among malnourished HIV positive adults has been observed in many studies carried out in different settings where there has been nutritional supplementation. [73]. The improvement in nutrition status has been registered not only when using RUTF but also lipid based nutritional supplements among HIV positive adults like was done in a study in Ethiopia conducted by Olsen and colleagues [194]. In some of these studies weight gain has been associated with better clinical and nutritional outcomes for the malnourished HIV positive patients that were receiving nutritional supplementation compared to those not getting supplementation [73,74,195].

In Uganda, the use of 'RUTAFA' – a locally produced RUTF – for nutritional supplementation of malnourished HIV positive patients approved by the Ministry of Health was widely used during the time of the study. Anecdotal information from health care providers indicated that there were reported benefits realized by patients who receive RUTAFA as part of their nutritional rehabilitation. There was self-reported improvement in the health status of the participants including better appetite and reduced occurrence of illnesses. The improved-reported health status was associated with improvement of the nutritional status of the participants. Unfortunately, I was not able to document the changes in the viral load and CD4 count of the participants as these were not routinely performed at the time of the study. Hence I was not able to know the changes in the immunological status of the participants and its association with their health and nutritional status.

Apart from gaining of weight observed among the malnourished HIV positive adults recruited into the study, there was a great reduction in the number of participants who reported having ill health

within the past four weeks when they were last seen. As has been observed in other studies, the improvement in the reported health status could have been a good contributor to their improved nutritional status [76]. The improvement in the reported health status could be attributed to (a) better immunity due ARVs (b) better treatment of secondary infection that malnourished HIV positive adults were receiving as well as (c) the contribution from the nutritional care.

Gender differences in treatment outcomes, responses and mortality has been also observed. In most of these studies, male participants have tended to have poorer results especially as far as treatment outcomes are concerned with some of the reasons suggested being the noticed delays among males to seek treatment, care and support for HIV/AIDS.

HIV impairs nutritional status by undermining the immune system thereby allowing secondary infection which decreases nutrient intake, absorption and use. The provision of ART and nutritional rehabilitation has been shown to increase chances of recovery especially among patients who are severely wasted and with various opportunistic infections [96,97]. Furthermore, HIV positive adults on ARV treatment and nutritional supplementation have been shown to have enhanced weight gain and better treatment outcomes [98]. During the study it was observed that those participants on ARVs gained more weight within the first four weeks of being in the nutritional rehabilitation programme compared to those not on ARVs. The synergistic effects of ARVs on improving the nutrition status since the reduction of the viral load would reduce the body metabolic demands with the save energy being stored as body fat hence the weight gain. In this study it was observed that there is short-term quick weight gain and possibly recovery for HIV malnourished HIV positive adults who are both on ARVs and provided additional nutritional therapy. However after 4 weeks, there is similarity in the weight gained for both HIV positive adults on ARVs and those not taking ARVs.

7.3 Change in dietary diversity and food security of malnourished HIV positive adults undergoing nutritional rehabilitation in the Kyegegwa longitudinal study

This study showed that malnourished HIV positive adults undergoing nutritional rehabilitation had improvement in their dietary diversity despite no improvement in their household food insecurity status. Most participants ate at least 5 foods from different food groups but only a few ate fruits, vegetables and animal proteins.

Several studies have shown that dietary diversity is associated with high socioeconomic status. People with high income have the economic ability to purchase different types of foods from different food groups whereas those with low income mainly eat the cheaper foods available and this limit diversification [129]. However, in this study the changes in dietary diversity would be as a result of the improvement in the appetite and not having diseases like vomiting and diarrhoea hence the participants able to eat the different foods. Furthermore, with the nutritional education that the participants received this might have contributed to them being aware of the need to eat different foods to improve their nutritional status.

Gender differences have been observed in the dietary diversity and thought to be one of the reasons contributing to the poor treatment outcomes and nutrition status of HIV positive males in the ART programmes [121]. There have also been studies showing that women usually may have poor dietary diversity compared to men because of not being able having the ability to get different foods as they have lower incomes compared to the men [178]. However, in this study there were no gender differences observed in the dietary diversity of the malnourished HIV positive during the four visits of the study. There were similarities in the different foods eaten and the reported number of meals that were consumed by the participants.

Dietary diversity has been sometimes described as a food security indicator [170]. The ability of eating foods from different food groups has been associated with having food security access. With the good food security access someone is able to eat foods from a number of food groups [170] However in this study we observed that despite the improved dietary diversity, there were no major differences in the reported household food security over the 16 weeks period of the study. Apart from the nutrition supplementation, participants also received nutrition education and advise on eating foods from different food-groups. The increase in the dietary diversity could be because of the behavioural changes as a results of the information received and not necessarily an increase in the access to the different foods.

Seasonality and its relationship to nutritional status, household food insecurity and dietary practices of individuals have been studied extensively. Significant seasonal variations with changes in weight, clinical diagnosis of malnutrition, iron status and even growth velocity among children has been demonstrated [174 – 177]. An in-depth research study done Ghana showed that food insecurity was more severe in HIV-positive than in HIV-negative farm households in both in both the post-harvest and lean seasons [178]. For our longitudinal study, data was collected for a period of eight months which spanned through the harvest and post-harvest seasons. Unfortunately, seasonality was not one of the variables that we tested in our analysis. However, it is plausible to say that changes in food availability as per the household food security assessments and the corresponding dietary practices of the participants could have been affected by the changes in the farming seasons. In Uganda, many communities experience seasonal variations in their household food security which affects their dietary diversity [196]

7.4 Changes in bioelectrical impedance parameters and their correlation with body mass index for malnourished HIV positive adults

The results from this study showed an increase in the BIA values of participants during the 16 weeks of follow up. The increase in the mean values for the BIA parameters were gradual over the past the 16 weeks which could imply betterment of the health status of the participants. In particular, the increase in phase angle for both male and female malnourished HIV positive adults was statistically significant. There was absolute increase in the mean values of other BIA parameters like reactance, resistance, resistance and reactance adjusted for height although the changes were not statistically significant.

In particular, as had been observed with the changes in weight, similarly change in phase angle was higher among males compared to female participants with the difference between the mean values being statistically significant ($p<0.05$). Female participants had higher increase in the R/H values which greatly affected their R/Xc graphs. There was also observed difference in the mean change of the phase angle for participants who were on ARVs at the time of recruitment into the study and those who were not on ARVs was minimal and not statistically significant.

As has been observed in other studies where phase angle has been investigated, the observed changes in phase angle for participants of Kyegegwa longitudinal study could imply a healthier quality of the lean tissue that the participants were accumulating on as they gained weight as a result of improvement in their nutritional and health status. It has been described that phase angle is a linear method of measuring the relationship between electric resistance (R) and reactance (Rc) in series or parallel circuits, and so taking the arc tangent value of the ratio of reactance versus electric resistance provides us with the phase angle value [38]. Lower phase angles appear to be consistent with low reactance and equals either cell death or a breakdown in the selective permeability of the cell

membrane. There is a significant difference in phase angle between healthy and disease states. Thus phase angle increases with improving clinical status [155-157]. Gonzalez and colleagues have also recently shown that phase angle influences body composition of individuals. They found that age and a combination of FFM and height were the most important variables that explained the variability of phase angle [154].

There were variations observed in the R/Xc graphs first for male and female participants, and also for participants that had been on AVRs and not at the time of the start of the study do reflect the differences in the changes of reactance and resistance when adjusted for height for the different groups. Female research participants had higher values of resistance and resistance adjusted for height and an increase in their impedance values. These variations could indicate differences in the amount and quantity of muscle that was gained. The beneficial effects of the type of weight added on could possibly determine whether males or females gained fat or lean mass as was previously described by Norgan and Wells [197,198].

7.5 Changes in Hand Grip Strength of participants for the Kyegegwa longitudinal study

All participants had an increase in their hand grip strength over the 16 weeks of follow up compared to that at the time of admission in the study. The changes in HGS were statistically significant and the increase for males was higher in comparison for the female participants.

Hand grip strength has been observed to decrease during illnesses especially chronic diseases like HIV/AIDS, cancer among others and also poor nutritional status [190]. Furthermore, hand grip strength has been observed to correlate with an individual's physical capacities and functionality [190-193]. This study showed that malnourished HIV adults had very low HGS but which progressed during the 16 weeks of nutritional rehabilitation. The low HGS could be related to not only the HIV infection and poor nutritional status but the poor general health of the participants as

they reported having had many symptoms at the start of the study. It was observed that changes in HGS was correlated with changes in BMI an indication of a relationship between HGS and nutritional status of the participants.

In this study there was correlation between the changes in HGS and changes in resistance and resistance adjusted with height among male participants. However, there was correlation between HGS and phase angle indicating that HGS cannot be used to predict phase angle or the other way around. The study was conducted only for 16 weeks and this could have been a short time to get all the changes in the physiological markers of the individuals. This could have limited he realisation of all the changes that might occur over a period of time.

Chapter 8. Conclusion about the cross sectional and the Kyegegwa longitudinal studies

8.1 Conclusion from the two studies

This study showed high rates of household food insecurity, low rates of dietary diversity and high malnutrition rates among adults the majority of whom were refugees living in Kyaka and Nakivale refugee settlements in Southwestern Uganda. In this population HIV infection was not a risk factor for household food insecurity but residence of the participants (geographical location) greatly influenced their household food security. The geographical vulnerabilities that may exist within the settlement might affect the nutrition and health status of the residents. It is important to find out those conditions that might increase the vulnerabilities of people living with HIV in being food insecure.

There was no association of household food insecurity with nutritional status based on either BMI or MUAC of the research participants. This possibly indicates that poor nutritional status was not as a result of food insufficiency alone but an indication of the socioeconomic status of the respondents which calls for the need to address malnutrition from different perspectives and not only the provision of food alone. Adults who were HIV positive were disproportionally affected by malnutrition and it was found that HIV infection was a risk factor for malnutrition among this population. This study shows that being refugee and HIV positive may increase ones vulnerability towards poor nutrition status and this would greatly impact negatively on their health status and possibly their survival. These findings call for the need to review the vulnerability criteria used among refugees to provide them extra assistance and support. I am urging that HIV infection and assessment of the household food security status of PLHIV should be part of the vulnerability assessment. This will ensure that necessary support is provided to PLHIV to improve their care, treatment outcomes and possible risk of spreading HIV through engagement in risk behaviours.

The high levels of low dietary diversity seen among this population and more-so those infected with HIV needs urgent intervention. Nutrition education needs to be intensified to provide people especially those leaving with HIV with appropriate and practical information. There is need to educate refugees on practical ways to improve the quality of their diets for example through growing of vegetables and promotion of practices like 'kitchen gardens' that may not require big land to be implemented.

Malnourished HIV positive adults gained weight during their 16 weeks of stay in the nutritional rehabilitation programme however the gender differences observed with women gaining less weight compared to men calls further investigation. The malnourished HIV patients gained weight, MUAC hand grip strength implying better functionality and all these parameters were more pronounced among males. However even when there were noticed improvements among the malnourished HIV adults, at 16 weeks of nutritional rehabilitation they still had lower indices compared to HIV negative participants. This could be an indication that the malnourished HIV positive adults were still far from their recovery from HIV and its associated opportunistic infection and good nutrition state.

It is possible to directly use the impedance data to provide useful information on the nutritional and clinical status of malnourished and HIV positive adults. There were observed differences in the BIA parameters – phase angle, reactance and resistance – among those malnourished or those with HIV infection. There were significant changes of phase angle observed among malnourished HIV positive adults and an indication of improvement in the nutritional status of the participants. Having reference data would enhance the usefulness and practicability of using BIA parameters within populations in resource poor settings. The changes of phase angle were correlated with changes in BMI however other BIA parameters did not correlate with changes in weight or hand grip strength. The variations in the change of phase angle, reactance, resistance and impedance that was observed among male and female participants of the longitudinal study could signify differences in the type of weight gained

either lean mass or fat mass. This could also depend on the physiological and metabolic benefits for males and females and response to the HIV infection and malnutrition. These issues need to be further investigated among malnourished HIB positive adults.

The Kyegegwa longitudinal study showed that malnourished HIV positive adults gained weight which helped then to improve their functionality as was observed by increase in their hand grip strength. Furthermore, they had a significant increase in their phase angle but non-significant reactance, resistance and impedance. This could indicate improved quality of their cell integrity but less on the quantity of their lean cell mass. However, having a study going beyond the 16 weeks of observation could help in explaining more the usefulness of these BIA parameters and their relationship in the monitoring nutrition and clinical status of malnourished HIV positive adults.

8.2 Limitations of the studies conducted

The cross sectional and observational nature of this study means that I can only make associations between the different findings. Nevertheless, the findings of the cross sectional study provided some insight about the high prevalence of household food insecurity, poor dietary diversity and malnutrition among the refugees and other residents of Kyaka and Nakivale refugee settlements.

Having HIV positive and negative participants, from different nationalities (Ugandans and refugees) and from two different geographical sites (Kyaka and Nakivale refugee settlements) provided a good mixture in the sample used for the study making comparisons between the different groups and locations. At the same time, having a study investigating different aspects of nutritional status, body composition, food intake, dietary diversity and household food security access enabled us to get a great deal of nutrition-related information essential in understanding different ways of improving nutritional status among PLHIV.

The data for dietary intake and household food access was based on self-reported information from the participants. This has the danger of recall bias with the possibility of some of the participants having forgotten what they ate or the experiences they had regarding accessing food. For example it is possible that some refugees and HIV positive participants who may want to be given food aid because of their status might want to portray themselves as not having enough food to eat and end up exaggerating their experiences.

For this study, I used the HFIAS and IDDS tools which have been validated and recommended for use in several settings and for different kind of research participants including HIV positive people [68]. However the specificity and sensitivity of the HFIAS tool when used among refugees who might be inherently food insecure and expecting food aid needs to be further explored and compared with other available food insecurity measuring tools. Furthermore, assessing food intake and household food access could be combined with some other quantitative measures for nutritional adequacy and documenting of food supply, availability and utilisation as well using qualitative methods to provide more insight about the possible reasons why some of the HIV refugees are food secure or not and their knowledge about nutrition in general and the recommended feeding practices during diseases like HIV.

Bioelectrical analysis data is said to vary depending on the hydration status, level of physical activity and time of the day. The big sample size and the repeated measures for the longitudinal study ensured that errors due to the possible variations were minimized. Because of HIV infection and other unknown diseases among the participants could affect their hydration status. The use of raw bio impedance data provided an opportunity to directly use the BIA observations with limited concern about the hydration status of the participants.

During the longitudinal study, participants were only followed up for 16 weeks. This period could have been short considering that some of the physical and biological changes in the body take more time to be realized.

8.3 Possible usage of the findings from the two studies in the management of malnutrition among people living with HIV

The information generated is useful for programme staff working with refugees in nutrition and HIV programmes. The results highlight the need among health care providers and programme staff that the prevalence of undernutrition prevalence is high and associated with poor food insecurity. These situations increase the vulnerability of PLHIV and could affect their clinical outcomes and overall quality of life if not addressed. There is hence great need to have nutritional education and support programmes embedded within HIV/AIDS activities.

The use of BIA data for nutritional assessment and monitoring among PLHIV and especially in developing countries is still limited. These studies showed that using BIA data especially phase angle could be helpful and is one of the easier ways in assessing prognosis and response to treatments and nutritional support provided to PLHIV.

8.4 Future possible research

Undertaking a study that assesses dietary intake and nutritional adequacy among HIV positive adults would provide more insight in the link between food security, intake and nutritional status. Knowing this linkage could be important especially in identifying PLHIV who would benefit from support considering the limitations in resources.

The use of IDDS and HFIAS tools among refugees and HIV positive adults needs to be further investigated. The research could also test the specificity and sensitivity and compare these tools with others like CSVA commonly used by WFP. There would be need to develop and testing the effectiveness of a simple, user friendly tool for the clinicians to measure food sufficiency and quality of food eaten among HIV infected adults and those with other infectious and chronic diseases.

Developing a population based reference for bioelectrical impedance parameters like phase angle would help in knowing the cut off points especially when considering the use of phase angle as a prognostic marker. There is need to explore the changes of BIA parameters over a longer period of up to six or twelve months and in a wide range of other chronic infections and malnutrition and associated co-morbidities.

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Appendixes

1. Graphs for changes in selected variables for each individual research participant during the four visits
2. Bio impedance measures for 5 volunteers. These volunteers had their bioelectrical impedance analysis conducted during different times of the day to test if time of assessment during the day affected the BIA parameters.
3. Questionnaires used for data collection
4. Ethical approval letter
5. Letter of consent for the research participants