KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

METABOLIC SYNDROME PARAMETERS AND THEIR ASSOCIATED FACTORS AMONG OLDER PRISONERS IN THE ASHANTI REGION OF GHANA

BY

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DECLARATION

I declare that I have independently carried out the research work presented herein under the supervision of Dr. Reginald Adjetey Annan and that with the exception of sections where citations have been made, this thesis is the result of my research.

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DEDICATION

"This is the doing of the Lord and it is marvellous in our sight" (Psalm 118:23). This work is dedicated to the Almighty God for His strength and mercies in seeing me through this work. Additionally this work is dedicated to the entire Agyapong family for their help and support both in kind and in cash and to my niece and nephews; Lady, Junior, Naana, Nana and Owura.

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ABSTRACT

Prison environments had been characterized by high rates of communicable diseases until recently when prevalence of non-communicable diseases have been assessed and high rates found especially among older inmates. This transition has been blamed primarily on inappropriate diets fed to inmates. In Ghana, little is known about diet and nutrient provisions and intakes among prisoners and their relationship with nutritional status and health. This study assessed food provision, dietary patterns and nutrient intakes and their relationship with metabolic syndrome among older prisoners. Household food record was used to estimate nutrients provision within the prisons and a single 24-hour recall was used to estimate the actual intakes of inmates. A total of one hundred and sixty inmates from the Kumasi central (131), Kumasi female (10) and Manhyia local prisons (19) were included in the study. Nutrient provision for protein, fibre, vitamin E, vitamin C, vitamin $B_{12,}$ folate and zinc were inadequate for male inmates but in excess for female prisoners. However, differences were observed between nutrient provision and actual intakes. This may be due to over or underestimation by inmates with a general probable underestimation. Metabolic syndrome was defined by the NCEP ATP III criteria. The mean systolic blood pressure of study participants was 141.1±23.2 mmHg, diastolic 88.9±15 mmHg, BMI 22.8±4.1kg/m^2, waist circumference 81±10.3cm, FBS 4.3±0.9mmol/L, HDL 1.4±0.4mmol/L and triglycerides 1.1±0.6mmol/L. The overall prevalence of metabolic syndrome was 8.1%; 61.9% had one metabolic parameter and 21.9% had two parameters. Correlational analysis revealed a weak positive relationship between sodium intake and serum triglyceride (r= 0.212, p= 0.007); potassium and systolic (r=0.172, p= 0.030) and diastolic blood pressure (r=0.164, p= 0.039), vitamin B_{12} (r= 0.226, p= 0.004) and folate (r=0.186, p=0.018) and systolic blood pressure. No association was found between nutrient intakes and metabolic syndrome. In conclusion, nutrients provided were outside ranges of recommendations and higher than actual intakes. Prevalence of dyslipidaemia and elevated blood pressure were high among inmates. Adequacy of prison diets should be checked in order to prevent deficiencies and excesses and resultant increase in morbidity and mortality. Further studies should assess serum levels of these nutrients in order to determine more concrete association.

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LIST OF ABBREVIATIONS

AI	-	Adequate Intake
AMDR	-	Acceptable Macronutrient Distribution Range
BMI	-	Body Mass Index
CAN lab	-	Clinical Analysis Laboratory
CHRPE	-	Committee on Human Research Publication and Ethics
CVDs	-	Cardiovascular Diseases
DASH	-	Dietary Approaches to Stop Hypertension
HbA1C	-	Haemoglobin A1C
HDL-C	-	High Density Lipoprotein Cholesterol
LDL-C	-	Low Density Lipoprotein Cholesterol
NCEP ATP III	-	National Cholesterol Education Programme Adult Treatment Panel III
RPM	-	Rotation Per Minute
RDA	-	Recommended Daily Allowance
TG	-	Triglycerides
WHO	-	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Metabolic syndrome is a group of physiological and biochemical anomalies associated with increased risk of cardiovascular diseases and Type 2 diabetes (Kaur, 2014). The factors that come together to be diagnosed as metabolic syndrome are strong modifiable risk factors for cardiovascular diseases (Scuteri *et al.,* 2015). The World Health Organization estimates that about 80% of all cardiovascular deaths occur in developing countries and are strongly attributed to modifiable risk factors (WHO, 2011). These modifiable risk factors include elevated blood pressure generally referred to as hypertension, diabetes or glucose intolerance, dyslipidaemia and central obesity (Toth *et al.,* 2016). Among these factors, hypertension is the prime risk factor for cardiovascular diseases and the third cause of death worldwide (Santulli, 2013). According to the National Cholesterol Education Programme, Adult Treatment Panel III, presence of at least any three of these factors within an individual satisfies the diagnostic criteria for metabolic syndrome and it is an important predictor of future mortality and morbidity (Lorenzo *et al.,* 2007). Presence of the syndrome within an individual predisposes significantly to type 2 diabetes and cardiovascular diseases (DeFina *et al.,* 2012); however, its individual parameters are also independent risk factors for these chronic conditions (Chirinos *et al.,* 2014; Trialists'Collaboration, 2014).

Together with cancer and chronic respiratory conditions, cardiovascular diseases and diabetes account for 63% of all global deaths (WHO, 2013). It is estimated that about 25% of the world's population have metabolic syndrome (Prasad *et al.,* 2012). The syndrome presents with impaired endothelial function and increased chances of blood clotting as a result of hype in platelet aggregation and altered regulation of coagulation and anticoagulation factors (Fuentes *et al.,* 2013). Risk of type II diabetes is due to alteration in the metabolism of

insulin, notably hyperinsulinaemia and resistance to insulin, which are hall marks of metabolic syndrome (Li *et al.,* 2013). Metabolic syndrome parameters have been shown to have some genetic associations but the role of diet and other lifestyle factors in their pathophysiology cannot be overlooked (Fulgoni *et al.,* 2013; Guess *et al.,* 2016; Xi *et al.,* 2013).

Prisoners form a sub group of the population who are more often than not part of the disadvantaged of the society. Most are reported to be unskilled, uneducated or with only basic education and are from low income backgrounds (Bautista-Arredondo *et al.,* 2015; Herrington, 2009). Over the years, more attention has been focused on the prevalence of communicable diseases and infectious diseases among prisoners, especially considering the effects of prison environment, such as overcrowding and insanitary conditions in spreading these infections (Mannocci *et al.,* 2014; Thomas *et al.,* 2016). Inadequate access to health care services and prejudice against prisoners in the provision of health care services also contribute to this outcome (Exworthy *et al.,* 2012; Pont *et al.,* 2012). Inappropriate personal hygiene and unhealthy practices expose prisoners to infections (Rop *et al.,* 2016; Shukla *et al.,* 2016).

Prisoners are more likely to be smokers or past smokers, alcohol abusers or past alcoholics which are risk factors for cardiovascular diseases (Jalilian *et al.,* 2013; Richmond *et al.,* 2013). Smoking for example is the leading risk factor for cardiovascular diseases worldwide and risk of cardiovascular disease is halved one year after the cessation of smoking (WHO, 2008). Prisons are stressful environments with meal provisions that predispose to cardiovascular diseases and its risk factors (Binswanger *et al.,* 2009; Hannan-Jones and Capra, 2016). Cardiovascular diseases have also become the leading cause of death worldwide prompting the need for assessment to be done among all groups be they incarcerated or free (Avendano *et al.,* 2006). It has also become a leading public health

concern with an amount of $ 531 billion as its care cost representing 75% of all public health cost (Vera-Remartínez *et al.,* 2014). Metabolic syndrome parameters predispose significantly to cardiovascular diseases. Globally, there is a general increase in the prison population with all prisons around the world exceeding their built up capacity (Walmsley, 2003). The world has a prison population of approximately ten million (Gessert and McCarty, 2013). Ghana as at the year 2013 had a total prison population of 14,021 as against its authorized prison capacity of 9,875 (Walmsley, 2003). This has worsened prison health conditions.

Most studies that looked at metabolic risk parameters among prisoners have documented a high prevalence rate. In a study conducted in Istanbul, it was documented that cardiovascular diseases are the most common cause of natural death among prisoners (Ünal *et al.,* 2016). Additionally Binswanger *et al.,* (2009) reported that in the United States, prisoners had a higher risk of cardiovascular diseases compared to the general population even with adjustments for important socio-demographic factors. Another study conducted in Australia also found higher prevalence of cardiovascular risk factors among younger prisoners compared to the general population (D'Souza *et al.,* 2005). A review of the disease profile of Nigerian prisoners revealed a high prevalence of cardiovascular diseases (Audu *et al.,* 2014). Furthermore, cardiovascular diseases rank second to drug abuse as the highest cause of death among ex-convicts (Binswanger *et al.,* 2007). A positive correlation between the length of stay in prison and the risk of developing cardiovascular diseases further bring to light the effect of the prison environment on the development of these metabolic risk factors (Silverman-Retana *et al.,* 2015).

The 2012 annual prison report of the Ghana Prisons Service indicated that cardiovascular diseases were the leading cause of mortality among inmates. In the 2013 report, cardiovascular diseases ranked second to anaemia as the highest cause of death (Ghana Prisons Service, 2012; Ghana Prisons Service, 2013).

Inappropriate diet, smoking, high alcohol consumption as well as physical inactivity have been outlined as the major causes of metabolic risk markers within prisons (WHO, 2014). Torture, which is a characteristic of prison life has also been associated with the occurrence of pro-inflammatory episodes and post-traumatic stress; which are both risk factors for cardiovascular diseases (Ghaddar *et al.,* 2016). Most prisons are usually overcrowded, understaffed and without enough security measures to permit the undertaking of physical activities by inmates (Plugge *et al.,* 2014). The negative impact of prisons' rules and routines on the management of cardiovascular diseases as well as its risk factors have also been mentioned by Thomas *et al.,* (2016).

Older inmates aged forty (40) and above are of an increasing concern with regards to cardiovascular risk and health status compared to younger ones (Ahalt *et al.,* 2013). This may be due to the fact that increasing age is an independent risk factor for cardiovascular disease, although the effect of prison environment such as stress and inappropriate diet cannot be overlooked (Berry *et al.,* 2012; Michaud *et al.,* 2013).

A publication by the World Health Organization has clearly outlined the need for frequent screening, provision of opportunities for exercise and provision of standard health care to prisoners as measures to reduce the prevalence of metabolic risk factors among this population (WHO, 2014).

However it is evident from the studies reviewed above that the global efforts at preventing and managing metabolic syndrome and its indicators in prisons have not been effective. This work assessed the prevalence of metabolic syndrome parameters and their associated factors among older prisoners.

1.2 Problem statement

Early assessment of metabolic risk factors for cardiovascular diseases is a very essential intervention strategy even when non- modifiable risk factors such as aging persist (Perk *et al.*, 2012). Most young adults in prison have been sentenced to hard labour and engage in much physical activity (Hayes *et al.*, 2012). However the scenario is not the case for older prisoners thus, exacerbating their risk of cardiovascular diseases related to inactivity. Negligence to the health care needs of older prisoners, as well as their vulnerability to depression have been implicated in the high prevalence of metabolic risk factors associated with them (O'Hara *et al.*, 2016). High prevalence of chronic diseases among prisoners adds to the cost of their basic care which is already a burden to governments, especially for developing countries (La Vigne and Samuels, 2012; Li, 2014; Schmitt *et al.*, 2010).

Mortality among Ghanaian prisoners is mainly attributable to cardiovascular diseases (Ghana Prisons Service, 2012). Early assessment of these risk factors can enable timely interventions to be implemented.

Most of the data on the prevalence and incidence of cardiovascular diseases and its risks factors among prisoners is from developed countries even though 80% of all global deaths from cardiovascular diseases occur in developing countries (WHO, 2014). Data on prevalence of cardiovascular diseases and metabolic risk factors among prisoners does not exist in Ghana and very little data is available for Africa as a whole. This has led to generalizations been made about the prison systems in Africa and in Ghana based on studies conducted in other countries. These generalizations may however not be applicable to Ghana, hence the need for this research work. It is in response to this need that this study assessed the prevalence of metabolic syndrome parameters and their related factors among older prisoners.

1.3 Research Question

What is the prevalence of metabolic syndrome parameters and what are associated dietary and nutritional factors among older prisoners in the Ashanti Region of Ghana?

1.4 Main objective

The principal objective of this cross-sectional study was to assess the prevalence of metabolic syndrome parameters and their associated factors among older prisoners in the Ashanti Region of Ghana.

1.5 Specific objectives

- To assess the diets fed to prisoners and whether these meet their Recommended Daily Allowances.
- To assess the prevalence of metabolic syndrome and its parameters among prisoners.
- To determine the relationship between dietary intake of participants and metabolic syndrome parameters.

1.6 Research Hypothesis

The prevalence of metabolic syndrome parameters among prisoners exceeds 40% and is therefore considered to be high.

1.7 Justification

Assessment of metabolic risk factors for cardiovascular diseases among prisoners will provide information about the health conditions within Ghanaian prisons. This project provides data to fill in the knowledge gap and also inform policy makers regarding the need for intervention to prevent or delay the incidence of metabolic risk factors in correctional

facilities. Ultimately, this will reduce morbidity of inmates which pose a huge economic burden to the government.

Availability of this data also addresses the World Health Organisation concerns about scarcity of data on this subject in Africa. It also provides information that is representative of the Sub-Saharan prison system to inform the World of the prevalence of metabolic risk parameters and factors contributing to these risks.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Metabolic Syndrome

The last century has been challenged with a high burden of cardiovascular diseases with more efforts and researches been tailored toward the control of this global pandemic (Serné *et al.,* 2007). Several factors and conditions predispose an individual to cardiovascular diseases, however a combination of several risk factors that can simultaneously present within an individual have been defined (Grundy, 2007). This is known as metabolic syndrome. Among the parameters constituting the syndrome are elevated blood pressure generally referred to as hypertension, diabetes or glucose intolerance, dyslipidaemia and obesity. Though the above mentioned features are universally accepted to constitute metabolic syndrome, different organizations and expert groups have varying definitions (Grundy, 2008; Kaur, 2014; Lorenzo *et al.,* 2007).

The National Cholesterol Education Programme, Adult Treatment Panel III (NCEP ATP III) defines metabolic syndrome as the presence of any three or more of elevated blood pressure (≥ 130 mmHg systolic and or ≥ 85mmHg diastolic), impaired fasting plasma glucose (≥ 5.6mmol/L), decreased high density lipoproteins (< 1.03mmol/L), elevated triglycerides (≥ 1.7mmol/L) and central obesity (waist circumference ≥ 102cm in men and ≥ 88cm in women). The International Diabetes Federation definition is similar to that of the NCEP ATP III, except for the categorization of waist circumference cut off points by race (≥ 94cm in non-Hispanics, ≥ 80cm in Mexican-American women and ≥ 90cm in men) and the absolute requirement of increased waist circumference in addition to any two of the other parameters. At the core of the definition of the syndrome in accordance with World Health Organization criterion is insulin resistance; fasting insulin levels greater than the 75^{th} percentile or impaired glucose tolerance (fasting plasma glucose ≥ 6.1mmol/L) or diabetes mellitus. Addition of

any two of the following to the afore mentioned is diagnostic of metabolic syndrome by WHO standards; increased waist circumference (waist to hip ratio >0.9 in men and >0.8 in women), body mass index within the obese range (≥ 30kg/m^2), dyslipidaemia (serum triglycerides ≥ 1.7 mmol/L, high density lipoprotein < 1.0mmol/L in women and < 0.9mmol/L in men) and high blood pressure (≥140 mmHg systolic and or ≥ 90mmHg diastolic) (Kassi *et al.,* 2011).

Expert group	Definition of metabolic syndrome
WHO	Insulin resistance; fasting insulin levels greater than the 75th percentile or impaired glucose tolerance (fasting plasma glucose ≥ 6.1mmol/L) or diabetes mellitus plus two of increased waist circumference (waist to hip ratio >0.9 in men and >0.8 in women), body mass index (≥ 30kg/m^2), dyslipidaemia (serum triglycerides ≥ 1.7 mmol/L, high density lipoprotein < 1.0mmol/L in women and < 0.9mmol/L in men) and high blood pressure (≥140 mmHg systolic and or ≥ 90mmHg diastolic)
NCEP ATP III	Three or more of elevated blood pressure (≥ 130 mmHg systolic and or ≥ 85mmHg diastolic), impaired fasting plasma glucose (≥ 5.6mmol/L), decreased high density lipoproteins (< 1.03mmol/L), elevated triglycerides (≥ 1.7mmol/L) and central obesity (waist circumference ≥ 102cm in men and ≥ 88cm in women).
INTERNATIOLNAL DIABETES FEDERATION	Central obesity (≥ 94cm in non-Hispanics, ≥ 80cm in Mexican-American women and ≥ 90cm in men) plus any two of elevated blood pressure (≥ 130 mmHg systolic and or ≥ 85mmHg diastolic), impaired fasting plasma glucose (≥ 5.6mmol/L), decreased high density lipoproteins (< 1.03mmol/L), elevated triglycerides (≥ 1.7mmol/L)

It is estimated that about 25% of the world's population have metabolic syndrome (Prasad *et al.,* 2012). In Africa, prevalence of metabolic syndrome ranges between 0-50% and is dependent on the population under study (Okafor, 2012). According to the National Health

and Nutrition Education Survey, variations in the prevalence of metabolic syndrome exist among different age groups and high prevalence is directly proportional to increasing age; 10% among age 20-25, 20% among age 40- 49 and 45% among age 60-69. Blacks are at a higher risk of metabolic syndrome compared to their white counterparts and within the black group, female gender poses an even greater risk (Grundy, 2008; Park *et al.*, 2003). In a study conducted in Ghana, a metabolic syndrome rate of 18% was found among study controls (Akpalu *et al.,* 2011).

The pathophysiology of metabolic syndrome is not fully comprehended (Alberti *et al.,* 2009; Grundy, 2011) but insulin resistance and central obesity appears to commence the series of events leading to the development of the syndrome (Esser *et al.*, 2014; Misra and Khurana, 2008; Samson and Garber, 2014). Insulin resistance leads to hyperglycaemia. As a result of decrease in glucose uptake, lipolysis occurs as a compensatory mechanism for energy production. This leads to elevated levels of low density lipoproteins and triglycerides. Visceral adiposity facilitates the mechanism leading to atherogenic dyslipidaemia. High density lipoproteins become a more preferred alternative for hepatic gluconeogenesis leading to its reduction at serum level (Kaur, 2014). Insulin regulates visceral fat breakdown and its resistance propagates visceral fat lipolysis (Jung and Choi, 2014). Blood pressure is raised as a result of the activation of renin angiotensin system in adipocytes (Cassis *et al.,* 2008; White *et al.,* 2016). Release of adipokines and free fatty acids from visceral fat cause decline in endothelial function and is a significant predisposition to atherosclerosis and hypertension (Huang, 2009; Serné *et al.,* 2007). In addition, insulin acts as a vasodilator to some extent and resistance to its action can raise blood pressure (Cornier *et al.,* 2008). Central obesity can also lead to hypo perfusion of adipocytes triggering an inflammatory response that also leads to atherosclerosis (Goossens, 2008).

These form the basis of the pathophysiological framework of metabolic syndrome, even though other related pathologies such as high levels of uric acid, hormonal abnormalities and microalbuminuria have recently been mentioned (Alberti *et al.,* 2006; Koborová *et al.,* 2015; Nagahama *et al.,* 2014; Yuzvenko, 2016).

Presence of any of the metabolic syndrome characteristic is a risk factor for cardiovascular diseases though the syndrome doubles the risk of occurrence of cardiovascular events in a space of five to ten years (Alshehri, 2010).

2.2 Metabolic syndrome parameters

2.2.1 Obesity

Prevalence of obesity has increased worldwide and threatens the global health system. Both developed and developing countries are challenged with the increasing rates of obesity (Bhurosy and Jeewon, 2014). Among developed countries, obesity is associated with lower spending power while the opposite is true for developing countries. Also, obesity in developing countries is associated with urban life while no significant differences exist in both rural and urban communities for developed countries (WHO and Consultation, 2003). Obesity is a major risk factor for non-communicable diseases like hypertension, diabetes mellitus, cerebrovascular accident, cancer and cardiovascular diseases and is conceptualised to begin series of anomalies that result in metabolic syndrome (Matsuda and Shimomura, 2013; Strasser, 2013; Youn *et al.*, 2014). Snacking, high intakes of simple sugars and high fat foods as well as physical inactivity account for the increase in obesity prevalence (Malik *et al.*, 2013).

Body Mass Index, waist circumference and waist-to-hip-ratio are common anthropometrics used for the determination of obesity. Body Mass Index determines overall body adiposity while waist circumference as well as waist-to-hip ratio predicts central obesity (Janssen *et al.*,

2004). Visceral adiposity is greatly associated with dyslipidaemia, impaired fasting plasma glucose and atherosclerosis (De Koning *et al.,* 2007; Sasaki *et al.,* 2016). Additionally, Sasaki *et al.,* (2016) found that elevated waist circumference in individuals with normal BMI poses a remarkable risk of insulin resistance. This in addition to other similar findings has led to the hypothesis that waist circumference is a better predictor of weight related health risk than BMI (Hajian-Tilaki and Heidari, 2015; Ma *et al.,* 2016). However a higher BMI is associated with increased risk of hypertension than elevated waist circumference (Gröber-Grätz *et al.,* 2013). The use of BMI together with waist circumference provides a detailed and more in depth information about state of health compared to the use of BMI alone (Nazare *et al.,* 2015). Most of the expert groups use waist circumference as a measure of the obesity component of the metabolic syndrome.

2.2.2 Hypertension

Hypertension is defined as systolic blood pressure ≥ 140 mm Hg and or diastolic pressure ≥ 90 mm Hg. Individuals who depend on antihypertensive medications to attain blood pressure within a normotensive range are also classified as hypertensive. Systolic blood pressure of < 120 mm Hg and diastolic pressure of < 80 is classified as normotensive. Individuals with blood pressure between the normal and hypertensive range are classified as pre-hypertensive (systolic blood pressure 120-139 mm Hg and or diastolic blood pressure 80-89 mm Hg) and stand a greater risk of developing hypertension and other cardiovascular events than normotensive subjects (Vasan *et al.,* 2001; Wang and Wang, 2004).

Additionally, hypertension is classified as either stage 1 hypertension (140-159 mm Hg systolic and or 90-99 mm Hg diastolic) or stage 2 hypertension (≥ 160 mm Hg systolic and or ≥ 100 mm Hg diastolic) (Giles *et al.,* 2005).

Hypertension is an important risk factor for both micro vascular and macro vascular complications (Appel *et al.,* 2006). Obesity, atherogenic diet, high intake of sodium and physical inactivity are prominent risk factors for hypertension but advancing age poses the most significant risk (WHO, 2016; Re, 2009). It accounts for 9.4 million deaths globally every year (Lisheng *et al.,* 2013). Hypertension in its earlier stages is mostly asymptomatic and many individuals are unidentified. The prevalence of hypertension is perceived to increase in the next decade especially in developing countries where most cases of hypertension are undiagnosed. The African sub region has the highest hypertension prevalence of 46% among individuals aged twenty five and older.

Prompt diagnosis, early and continual treatment is a more cost effective measure because complications of hypertension pose a huge economic burden (WHO, 2016). Body mass index within the normal range is protective against hypertension (Vaněčková *et al.,* 2014). A study conducted in the United States of America suggests that positive weight change among children and adolescents is directly proportional to elevated blood pressure (McGavock *et al.,* 2007). A five to ten percent (5-10%) decrease in weight even without the attainment of normal BMI lowers blood pressure (Mertens and Gaal, 2000). Inclusion of fruits and vegetables and whole grains helps lower blood pressure and prevent hypertension (Borgi *et al.,* 2016; Rebello *et al.,* 2014). Diet rich in fruits and vegetables can help maintain optimal blood pressure and health without reliance on supplements (Lichtenstein and Russell, 2005). Reduction of sodium intake is beneficial in reducing blood pressure especially for blacks and older individuals who are hypertensive or normotensive (Pimenta *et al.,* 2009). Reduction in alcohol intake to maximum of one drink per day for women and two drinks per day for men helps lower blood pressure (Whelton *et al.,* 2002). Several epidemiological studies suggest that reduction of alcohol intake to this level helps to lower blood pressure. Sleep disturbances and persistent stress can also lead to rise in blood pressure (Sparrenberger *et al.,* 2009).

2.2.3 Dyslipidaemia

High serum triglyceride levels and or reduced serum high density lipoproteins is an atherogenic lipid profile and is referred to as dyslipidaemia. These are the types of dyslipidaemia related to metabolic syndrome (Garrido *et al.,* 2009). Elevated low density lipoproteins cholesterol (LDL-C) also poses an important cardiovascular risk though not included in the diagnosis of metabolic syndrome (Sirimarco *et al.,* 2014). Oxidized LDL-C causes calcium retention within endothelial cells resulting in endothelial apoptosis and compromise in its protective role. HDL-C however reduces intracellular calcium levels maintaining endothelial integrity (Mineo and Shaul, 2012).

High density lipoprotein also has the ability to prevent LDL-C oxidation. Oxidized LDL-C is implicated in the formation of atheroma (Annema and von Eckardstein, 2013; Rye and Barter, 2014). Sirimarco *et al.,* (2014) found that additional drug therapy of fibrates together with statins increase HDL-C levels and is more effective in protecting against cardiovascular diseases compared to statins alone.

Elevated triglycerides is an uncommon risk marker among West Africans and most of those diagnosed with metabolic syndrome had lowered HDL-C, abdominal obesity and increased blood pressure (Sumner *et al.,* 2010). Optimal levels of HDL-C protects against atherosclerosis and cardiovascular mortality (Eren *et al.,* 2012; Fisher *et al.,* 2012; Ford and Liu, 2001; Lüscher *et al.,* 2014; Patel *et al.,* 2013). Even with patients treated aggressively for elevated LDL cholesterol; low levels of high density lipoprotein can lead to the occurrence of cardiovascular diseases (Acharjee *et al.,* 2013).

High intakes of whole grains, fruits and vegetables and a reduction in the amount of fat notably saturated fats helps to maintain normal lipid levels (Sharma, 2016).

2.2.4 Diabetes and Pre-diabetes

Diabetes and pre diabetes are as result of defect in the release or potency of insulin or both. This leads to consistent hyperglycaemia which can result in several disabilities such as blindness, amputations and a reduction in quality of life (American Diabetes Association, 2010). Diabetes essentially leads to abnormalities in the metabolism of the macronutrients namely fat, carbohydrate and protein (Craig *et al.,* 2009).

Fasting plasma glucose equivalent to or greater than 7.0mmol/L or 2 hour post prandial of greater than or equal to 11.1 mmol/L after ingestion of 75g glucose or Haemoglobin A1C (HbA1C) value of 6.5 or greater is diagnostic of diabetes mellitus. Fasting plasma glucose of less than 7.0mmol/L with a two hour post prandial glucose between 7.8mmo/L and 11.1mmol/L after ingestion of 75g of glucose refers to impaired glucose tolerance. Impaired fasting glucose refers to fasting blood glucose between 5.6 and 7.0mmol/L and two hour post prandial glucose of less than 7.8mmol/L. Impaired fasting glucose and impaired glucose tolerance are referred to as pre-diabetes and these predispose to diabetes mellitus. HbA1C value of 6.0-6.4 falls within a pre-diabetic range (Centre for Disease Control and Prevention, 2011; WHO, 2011).

Diabetes mellitus is generally put into three classes; Type 1, Type 2 and gestational. Type 1 diabetes occurs as a result of complete deficiency of insulin which is as a result of destruction of beta cells. Type 2 diabetes is as a result of partial insulin deficiency or insulin insensitivity or both. Gestational diabetes occurs during pregnancy and is resolved or proceeds to type 2 diabetes after delivery (Maraschin, 2013). Diabetes can also occur as a result of other factors such as organ transplant, drug or inherent defect in the action of insulin (Penfornis and Kury-Paulin, 2006).

Obesity, physical inactivity and advancing age are factors that can lead to the onset of diabetes (Barnett and Kumar, 2009; Morrato *et al.,* 2007). Insulin resistance leading to

diabetes is a main feature of metabolic syndrome and increases the risk of its occurrence (Meigs *et al.,* 2007).

2.3 Risk factors of metabolic syndrome

Risk factors of metabolic syndrome are categorized as modifiable and non-modifiable. Non modifiable risk factors include increasing age, family history or genetic susceptibility and gender. Inappropriate diet, smoking, chronic alcohol consumption and physical inactivity constitute modifiable risk factors (Wannamethee *et al.,* 2006).

2.3.1 Modifiable risk factors of metabolic syndrome

2.3.1.1 Dietary risk factors

Surplus caloric intake, high intake of saturated fats and physical inactivity are the main driving forces to the development of parameters that constitute metabolic syndrome (Edwardson *et al.,* 2012). Optimal nutrition plays an integral role in safeguarding against diseases throughout life and human disease has a close link with nutrition (English and Uller, 2016).

The role of both macro and micro nutrients in preventing or facilitating chronic disease is well documented. Inappropriate diet contributes significantly to cardiovascular disease and the dietary shift from foods of plant origin to processed caloric dense foods has contributed to rise in cardiovascular diseases and all non-communicable diseases (Mattei *et al.,* 2015; Singh *et al.,* 2014). High consumption of macronutrients leads to weight gain that can commence series of events leading to metabolic syndrome.

There is substantial data to support the protective role of fruits and vegetables against metabolic syndrome parameters and chronic non communicable diseases (Wang *et al.,* 2014). These contain antioxidants such as vitamin C and E that function directly to reduce

inflammation caused by reactive oxygen species (Gupta *et al.*, 2014; Pounis *et al.*, 2013). Whole grains are also protective against obesity and diabetes (Cho *et al.*, 2013). Mediterranean diet characterized by high fibre and low fat improves endothelial function and is therefore protective against metabolic syndrome and its associated cardiovascular risk (Schwingshackl and Hoffmann, 2014). Vitamin D protects against diabetes and other metabolic parameters (Ford *et al*., 2014; Reis *et al*., 2007).

The Dietary Approaches to Stop Hypertension (DASH) recommends the intake of dairy from low fat dairy sources as a measure to boost dietary calcium which guards against high blood pressure (Hikmat and Appel, 2014). Other trial studies found an inverse relationship between the DASH diet and metabolic risk factors for cardiovascular diseases (Hodson *et al*., 2010; Saneei *et al*., 2015). Magnesium regulates insulin secretion from pancreatic beta cells and is therefore vital for normal glucose homeostasis. Magnesium also averts stiffening of arteries which is a subclinical marker of atherosclerosis (Posadas-Sánchez *et al*., 2016).

2.3.1.1.1 Macronutrients

Macronutrients are the nutrients that provide the energy needed by the body to carry out its activities. They include protein, carbohydrate and fat (Hall *et al*., 2012).

Protein form basic structural components of human cells. Muscles and collagen are essentially protein. Collagen serves as a basic structure for teeth and bones (Ramachandran, 2013). Collagen strengthens blood vessels and enables them to withstand blood pressure (Sgarioto *et al*., 2012). Protein is also essential for the repair and build-up of worn out and dead tissues. Hormones, lipoproteins, haemoglobin and enzymes are essentially protein. Protein can also serve as a source of energy and excess is stored as fat (Munro, 2012).

Carbohydrate is the main source of energy for the body. Glucose serves as readily useable source of energy to brain cells (Bélanger *et al*., 2011). It provides the fastest and the cheapest

source of energy to the body (Cermak and van Loon, 2013). Adequate intake of carbohydrate spares proteins allowing them to carry out their functions (Groetch, 2013). It also allows fat to be broken down in a non-ketogenic manner (Schugar and Crawford, 2012). Complex sources of carbohydrate are more preferred to simple ones. Fibres form part of complex sources and helps lower cholesterol in the body and control weight gain (Kritchevsky and Bonfield, 2012).

Fat provides the highest amount of energy per gram. Fat is a source of energy to the body and also provides a medium within which fat soluble vitamins are transported within the body (Wiseman, 2013). Though fat has been implicated in the pathogenesis of several conditions, optimal intakes is essential to maintain health (Hooper *et al*., 2012). Fat provides warmth to the body and protects vital organs like the heart (Iacobellis *et al*., 2011). Cholesterol, a component of fat aids in nerve transmission and the formation of hormones. Polyunsaturated and monounsaturated fatty acids are protective against hypertension and cardiac arrhythmias. Only 10% of daily fat should come from saturated sources (Edelstein, 2014; Rolfes *et al*., 2014).

Energy requirements vary greatly among individuals. Factors that influence energy requirements include age, weight, height, gender and physical activity levels (Speakman and Westerterp, 2010). Energy balance is essential to maintain healthy weight and prevent obesity and underweight (Hill *et al*., 2012).

Excess intake of any of the macronutrients can lead to obesity and its attendant problems. Inadequate intake can also lead to drastic loss of weight and impaired immunity.

The acceptable macronutrient distribution range (AMDR) is based on scientific evidence and epidemiological studies that indicate that intake of macronutrients within these ranges guard against chronic diseases (Lee *et al*., 2015). The AMDR for carbohydrate is 45-65%, 20-35% for fat and 10-35% for protein. Other countries have also set their own AMDR based on

studies conducted within the populations. A study conducted by Lee *et al.,* (2015) found that intake of macronutrients within these suggested ranges reduce the risk of hypertension even after adjustment for smoking, age and other relevant factors.

Recommended daily allowance (RDA) is also based on scientific research and epidemiological data that suggest that intake of micronutrients and macronutrients within the said ranges protects against chronic, deficiency diseases and toxicities. The RDA of nutrients caters for the need of most individuals within the population. It is also worthy of note that the RDA is for healthy individuals and that people with co-morbidities may require more or less (Rolfes *et al*., 2014).

2.3.1.1.2 Micronutrients

These are nutrients that do not provide energy but are needed for the synthesis of energy from macronutrients, maintenance of health and proper systemic and organ function. Vitamins and minerals are micronutrients and these are required by the body in small quantities. Excess may lead to toxicities and insufficient amounts can result in deficiency and chronic diseases (Marks, 2012).

2.3.1.1.2.1 Folate, B12 and B6

Homocysteine is a metabolic by product that is poisonous or toxic to cells and can induce oxidative stress through inhibition of the natural antioxidant systems of the body or through the production of reactive oxygen species (Yilmaz, 2012). Removal of the methyl group from the amino acid methionine yields homocysteine (Mahalle *et al*., 2013). Homocysteine has been implicated in cardiovascular diseases and is hypothesized to be a novel risk marker for cardiovascular events (Scazzone *et al*., 2014).

Free radicals produced by homocysteine can induce endothelial dysfunction and increase susceptibility to atherosclerosis (Ganguly and Alam, 2015). This can subsequently lead to hypertension, cardiac failure, stroke and a host of other cardiovascular related diseases. Scazzone *et al.,* (2014) conducted a study and found that hypertensive patients had significantly higher levels of homocysteine and reduced serum folate compared to normotensive subjects. Certain congenital defects can lead to hyperhomocysteinaemia and its attendant problems. Folate, vitamin B_{12} and vitamin B_6 deficiency are risk factors for high serum homocysteine levels (Tanaka *et al*., 2009).

Folate, vitamin B_{12} and vitamin B_6 are essential for the metabolism of homocysteine and its subsequent reduction at serum level. Folate and vitamin B_{12} are essential for methylation of homocysteine to methionine. Vitamin B_{12} is essential for the transfer of the methyl group from folate to homocysteine (Kim *et al*., 2008). Methionine is gotten from the methylation of homocysteine and is in turn used for the synthesis of S-adenosyl methionine (Kirsch *et al*., 2009). S-adenosyl methionine does the provision of methyl groups to many compounds in the body enabling biochemical reactions to take place (Obeid and Herrmann, 2009).

Vitamin B_6 acts as a co-enzyme in the condensation of methionine and serine to form cystathionine (Taysi *et al*., 2015). These reactions ultimately help lower homocysteine and deficiency of any of these vitamins alters metabolism of methionine and subsequently increase homocysteine levels. Low serum B_{12} is linked to lipid abnormalities among type 2 diabetics (Adaikalakoteswari *et al*., 2014). Dietary supplements with B vitamins help reduce homocysteine levels but adequate dietary intake is more beneficial (Guallar *et al*., 2013; Ji *et al*., 2013). Recommended daily allowance for B_6, folate and B_{12} are 1.3mg/day, 400µg/day and 2.4µg/day respectively.

2.3.1.1.2.2 Vitamin C and Vitamin E

Vitamin C and E are very potent antioxidant micronutrients that are capable of stabilising free radicals. Free radicals build up lead to cellular disturbances and a reduction in nitric oxide (Sen *et al*., 2010; Shargorodsky *et al*., 2010). Nitric oxide is essential in maintaining endothelial and vascular structure (Münzel *et al*., 2010; Plantinga *et al*., 2007). Free radicals can also lead to the oxidation of fat which can subsequently cause atherosclerosis (Niki, 2014; Singh *et al*., 2015).

Antioxidants scavenge free radicals and thus prevent them from causing cellular and endothelial damage (Pham-Huy *et al*., 2008). This they do by donating electrons to free radicals in order to stabilise them. Antioxidants have the ability to remain fairly stable after donation of their electrons (Brewer, 2011). Vitamin E and vitamin C are essential nutrient antioxidants that can stabilise reactive oxygen species as a result of their ability to lose and gain electrons rapidly (Naziroglu *et al*., 2010).

Combined supplementation of Vitamin E and C is more beneficial compared to supplementation of either vitamin. Vitamin C is needed to help continuous restoration of Vitamin E which can exhibit pro-oxidant characteristics (Niki and Traber, 2012). A randomized controlled placebo trial conducted by Shargorodsky *et al.,* (2010) found that supplementation with vitamin C and E resulted in enhanced vascular elasticity and decreased blood pressure among study participants. Among diabetics, vitamin E supplementation was protective against cardiovascular diseases (Blum *et al*., 2010). The RDA for vitamin C is 90mg/day for men and 75mg/day for women. That for vitamin E is 15mg/day.

2.3.1.1.2.3 Potassium

Potassium is a major mineral that aids in the maintenance of fluid, electrolyte balance and normal cell physiology. Several population studies have documented the protective role of

potassium against hypertension. Current increase in hypertension and ultimately cardiovascular diseases may be as a result of shift from plant based foods to processed ones that are low in potassium (Aburto *et al*., 2013). The blood pressure reductive role of potassium is beneficial to both hypertensive and normotensive individuals (Houston, 2011).

Fruits and vegetables are richest sources of potassium (He and MacGregor, 2008). In the dietary approaches to stop hypertension (DASH) study, subjects who received the intervention of high vegetables and fruits, low fat diet saw a reduction of 5.5 mm Hg in systolic and 3 mm Hg in diastolic blood pressure. The reduction in blood pressure was also found to be sustainable among this group compared to controls (Appel *et al*., 1997). Other randomized trials and systematic reviews support the protective role of the DASH diet in protecting against hypertension (Epstein *et al*., 2012; Saneei *et al*., 2014). Potassium is protective against mortality from cardiovascular diseases (Umesawa *et al*., 2008). The adequate intake level for potassium is 4700mg/day.

2.3.1.1.2.4 Sodium

Sodium helps in the maintenance of fluid volume and acid base balance. It is also essential for nerve impulse transmission. Over the years, a positive correlation between sodium consumption and an increase in blood pressure has been well reported (Mizéhoun-Adissoda *et al*., 2017). Populations that consume high levels of sodium are at an increased risk of hypertension (He and MacGregor, 2011).

Sodium reduction has a double benefit of lowering blood pressure and preventing cardiovascular events (Cook *et al*., 2007). High sodium intakes can lead to cardiovascular diseases by facilitating oxidative damage (Whelton *et al*., 2012). Populations that consume low sodium diets maintain optimal blood pressure even as they age. The opposite is true for populations that consume high salt diets (Chang *et al*., 2006; He and MacGregor, 2010). High

salt intake leads to resistance to the action of antihypertensive medications and promotes hypertension complications (Pimenta *et al*., 2009). The WHO recommendation for sodium chloride is 5g/day as a measure to curb hypertension (WHO, 2015). The adequate intake level of sodium is 1500mg per day and 2300mg per day is the tolerable upper intake level.

2.3.2 Lifestyle factors

Sedentary behaviour increases the risk of metabolic syndrome by mainly promoting body adiposity (Ladabaum *et al*., 2014). Sedentary life style is associated with higher odds for metabolic syndrome (van der Berg *et al*., 2016). Physical activity improves cardio metabolic health and reduces significantly risk of developing metabolic syndrome (Gillen *et al*., 2014). Epidemiological studies suggest that lack of physical activity is a major cause of obesity and is associated with metabolic syndrome and other co-morbidities. A minimal of 60 minute of moderately intensified physical activity is recommended to maintain body weight and improve cardiac health (WHO and FAO, 2003). The American Heart association recommends at least 30 minutes of low intensive exercises per day throughout the week or most days of the week (Fletcher *et al*., 2013). This recommendation also reduces cardiovascular disease risk among individuals with metabolic syndrome. Active populations are healthier than sedentary ones and have low mortality as well as low prevalence of chronic conditions (Edwardson *et al*., 2012).

Cigarette contains harmful substances such as nicotine that can cause damage to endothelial lining and facilitate atherosclerosis (Rezk-Hanna *et al*., 2016). Chronic alcoholism can also lead to impairment in glucose control and increased cardiovascular risk (O'Keefe *et al*., 2007).

2.4 Non-modifiable risk factors

2.4.1 Increasing age

Increasing age is a major cause of compromised cardiovascular health. This is due to factors such as the thickening of the vascular walls of the heart and arteries with aging (Lakatta, 2002). This leads to increased cardiac output and elevated blood pressure. Serum cholesterol and homocysteine levels are higher in older compared to younger individuals and this further put older individuals at risk of cardiovascular disease (McCully, 2015). During the aging process insulin sensitivity is hindered and older persons become at an increased risk of glucose intolerance and diabetes (Chang and Halter, 2003).

2.4.2 Family history

Chronic diseases run through families and relations. Similar genetic make-up and or common lifestyle and dietary factors predict chronic diseases within families (Nelson, 2013). Genetic make-up such as the Ob gene in the case of obesity is inherited and passed on. Metabolism and storage of fats as well as glucose are similar among family members (Cederberg *et al*., 2014). Research shows that family members acquire similar chronic or cardiovascular conditions during their life time. Research by Cederberg *et al*., (2014) for instance indicates that a family history of diabetes put an individual at a twofold risk of diabetes.

2.4.3 Sex and Gender

Gender differences are associated with cardiovascular disease prevalence and outcomes (Regitz-Zagrosek *et al*., 2016). Males are documented to be at high risk of most chronic diseases compared to females. However mortality from cardiovascular diseases is higher among females (Anagnostis *et al*., 2015). These differences are due to differences in the biological make up notably in gene expression and hormonal activities (Legato and

Bilezikian, 2004). Differences in lifestyle observed among male and female may put one gender at a higher risk than the other. Lifestyle factors such as smoking and alcohol abuse are more common in men than in women (Ferguson *et al*., 2016; Jackson *et al*., 2015).

2.5 Risk factors of metabolic syndrome among prisoners; a systematic review.

Several studies have assessed cardiovascular risk prevalence among prisoners. These studies however have been unequally distributed with developed countries being ahead with respect to the number of studies conducted but 80% of all cardiovascular diseases occur in developing countries (Plugge *et al.*, 2014).

2.5.1 Search strategy

PubMed, PubMed Central, Google scholar, Cochrane and Medline databases were searched from a period of 6th June 2016 to 23rd June 2016. The search was made on already drafted protocol and the search words included cardiovascular diseases and prisoners, hypertension and prisoners, obesity and prisoners, dyslipidaemia and prisoners, diabetes and prisoners and cardiovascular risk factors and prisoners. Pubmed database was searched on the 6th of June, Google scholar was searched from a period of 13th June to the 21st of June, Cochrane, Medline and Pubmed Central databases were searched from the 21st of June to the 23rd of June.

2.5.2 Inclusion and Exclusion Criteria

Studies published from a period of 2012 to 2016 that looked at the presence of one or more cardiovascular risk factor among prisoners met the inclusion criteria. A similar systematic review by Herbert (2012) included earlier studies. Studies that looked at ex-prisoners or individuals in police cells were excluded.

2.5.3 Search results

Online search yielded a total of fifty eight thousand five hundred and eighty seven papers (58587) papers. Fifty eight thousand five hundred and forty four (58544) studies were rejected based on titles or being duplicates. A total of forty three (43) appropriately titled studies qualified to be included in the study but twenty one (21) were rejected based on their abstracts or because they were reports of other studies conducted. Five (5) of the studies could not be included because full texts were not available. Seventeen (17) studies that met inclusion criteria in terms of abstracts and methodology were included in the study. Refer to figure 2.1.

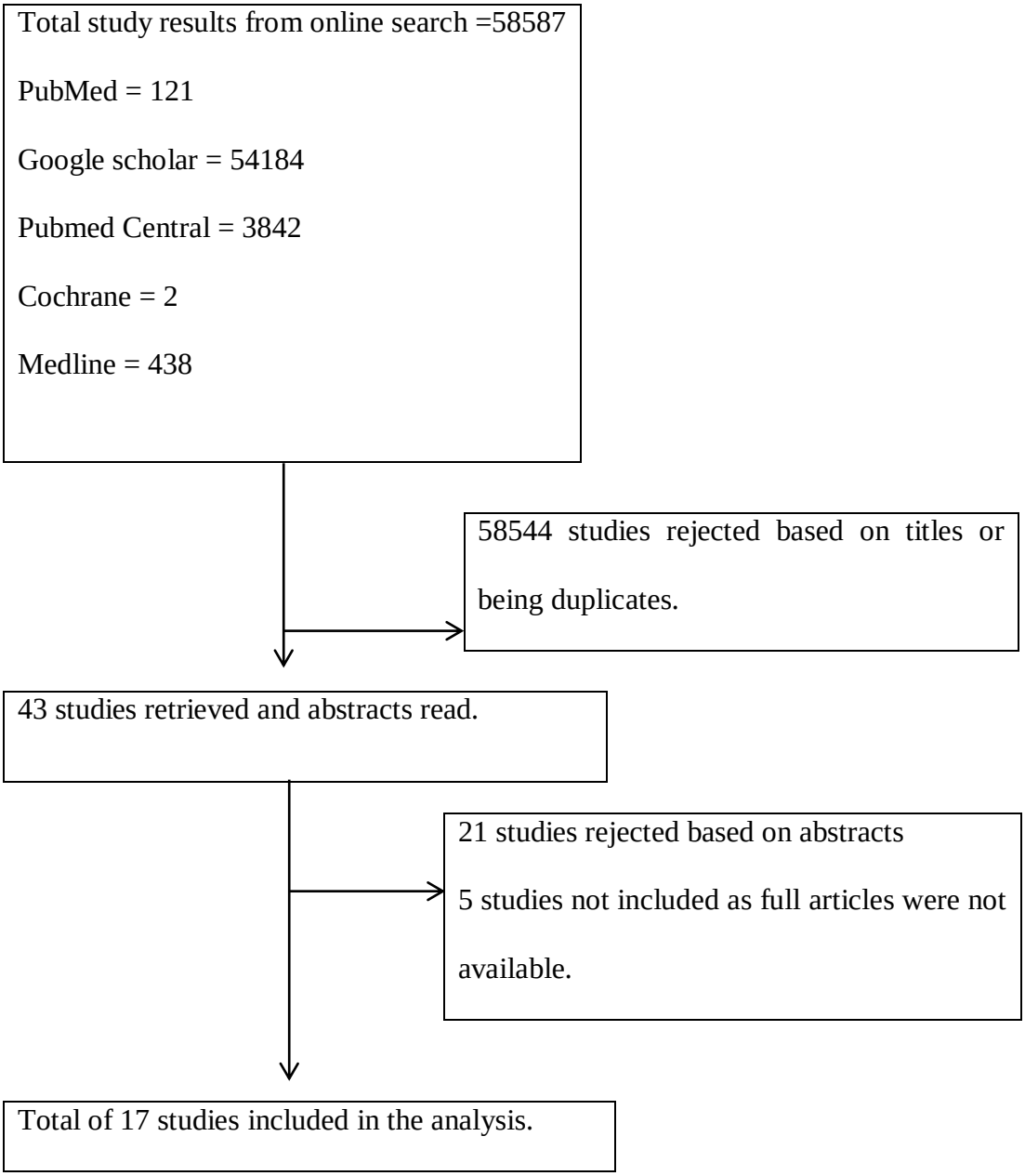

Figure 2.1 Selection Process for papers

2.5.4 Extraction of Data

Data was extracted based on the following criteria;

- Study source (Author, year of publication)
- Country in which study was conducted
- Study design
- Data collection procedures

- Number of participants
- Gender of participants
- Mean age of participants
- Major findings

2.5.5 Study designs

A total of seventeen (17) studies involving twenty five thousand, five hundred and ninety eight (25598) inmates were included in the review with most of them being cross sectional studies (70.6%). Most of the studies were conducted in developed countries with USA being the centre for most studies (41.2%), followed by Australia (11.8%) and Pakistan (11.8%). Majority of the studies assessed weight (64.7%), height (64.7%), BMI (64.7%) as well as blood pressure (17.6%) of inmates. Questionnaire (35.3%) and interview (58.8) were the most common tools for data collection.

The most common cardiovascular risk parameters looked at included obesity (64.7%), substance use (53%), diabetes (47.1%), hypertension (41.2%), dietary factors (41.2%) and dyslipidaemia (29.4). Two (2) studies purely looked at prison menus and dietary risk factors that contribute to cardiovascular diseases. Twelve (12) of the studies were cross sectional, one (1) was a retrospective longitudinal study, one (1) was prospective cohort study and another was a multicentre descriptive cross sectional study. Two (2) of the studies used secondary data and one (1) collected qualitative information via focus group discussions.

The studies were published from the period of 2012 to 2016 with most study participants being male prisoners (92.3%).

2.5.5.1 Quality Assessment

Quality assessment was done based on study methodology. Appropriate categorization of measurements such as blood pressure, Body Mass Index (BMI) was awarded highest marks. Also the kind of data used in the study was assessed with studies that made use of primary data being awarded highest marks

2.5.6 Findings

2.5.6.1 Overweight and obesity

A total of eleven studies assessed prevalence of overweight and obesity among inmates. Weight change has been associated with prison environment with all studies reporting a positive change in BMI during incarceration and high prevalence of overweight and obesity among prisoners (Clarke and Waring, 2012; Fawad *et al.,* 2012; Gates and Bradford, 2015; Haysom *et al.,* 2013; Leigey and Johnston, 2015; Mukhtar *et al.,* 2013; Silverman-Retana *et al.,* 2015; Togas *et al.,* 2014; van Dooren *et al.,* 2013; Vera-Remartínez *et al.,* 2014; Wolff *et al.,* 2012). The overall prevalence of overweight and obesity reported by all studies was 35.6 and 23.3 respectively.

Abdominal obesity which is a core metabolic syndrome parameter was also found to be high among study participants with an overall prevalence of 37.8 reported by three studies (Clarke and Waring, 2012; Fawad *et al.,* 2012; Vera-Remartínez *et al.,* 2014). The prevalence of central obesity reported were 36.3, 60.0 and 17.2 respectively. Increased weight and positive BMI change associated with prison environment is taught to be due to factors such as intake of psychotic drugs to treat mental problems, disordered eating patterns in response to stress and cessation of smoking upon entering prison (Clarke and Waring, 2012; Haysom *et al.,* 2013; Togas *et al.,* 2014) however, Wolff *et al.,* (2012), found no significant difference in positive weight change between inmates with mental disorder and those with no mental

disorders. Nevertheless, inmates with mental health disorders were more likely to be on drugs for cardiovascular diseases. Most participants in the various studies had one mental disorder or another (Alves *et al.,* 2015; Haysom *et al.,* 2013; Togas *et al.,* 2014; van Dooren *et al.,* 2013; Wolff *et al.,* 2012).

Gender differences have been found to be significant with respect to weight change with female inmates gaining more weight than their male counterparts (Gates and Bradford, 2015; Vera-Remartínez *et al.,* 2014; Wolff *et al.,* 2012). Mean BMI change reported in the Gates and Bradford (2015) study for both female and male were 5.34 (CI 4.63, 6.05) and 0.67 (CI 0.65, 0.69) respectively. This can be explained by high prevalence of sedentary lifestyle observed in female inmates (Vera-Remartínez *et al.,* 2014).

Length of stay was also observed to be significantly associated with weight change with drastic positive changes occurring within the first few weeks of incarceration (Clarke and Waring, 2012; Gates and Bradford, 2015). Silverman-Retana *et al.,* (2015) however found that length of incaceration was associated with decrease in BMI but the association was U-shaped. Longer length of stay is associated with healthy weight (Leigey and Johnston, 2015) and positive weight change is more prevalent among older inmates (Silverman-Retana *et al.,* 2015). One study however found that longer stay, greater than one year was associated with higher risk of obesity; seven times higher compared to those who have stayed for shorter periods. (AOR 6.92; $P < 0.001$) (Haysom *et al.,* 2013).

2.5.6.2 Dietary risk factors

Seven of the studies assessed dietary risk factors but two delved more deeply into prison menus. Prison foods are characterized by high saturated fats, high sodium and low vitamins and minerals and did not meet the nutritional needs of inmates (Alves *et al.,* 2015; Collins and Thompson, 2012; Cook *et al.,* 2015; Fawad *et al.,* 2012; Haysom *et al.,* 2013; Leigey and

Johnston, 2015; Mukhtar *et al.,* 2013; Silverman-Retana *et al.,* 2015). Vegetables and fruit intake were also below the recommended daily allowance (Collins and Thompson, 2012; Cook *et al.,* 2015; Fawad *et al.,* 2012; Mukhtar *et al.,* 2013). However, macronutrients were reported to be in the suggested ranges of the acceptable macronutrient distribution range (Collins and Thompson, 2012; Cook *et al.,* 2015).

Two studies reported that average sodium intake was above the tolerable upper intake level; the level above which toxicities to a nutrient can be observed (Collins and Thompson, 2012; Cook *et al.,* 2015). Sodium provision reported was 3393.5 mg and 4542mg respectively (Collins and Thompson, 2012; Cook *et al.,* 2015). The tolerable upper intake of sodium is 2300mg.

Total caloric provision was found to be significantly high for female inmates which may explain their likelihood of weight gain (Clarke and Waring, 2012; Cook *et al.,* 2015; Vera-Remartínez *et al.,* 2014). In addition to this, items sold at the prison stores are more often than not high in fat and sodium but low in vitamins and minerals worsening the plight of prison foods (Cook *et al.,* 2015).

2.5.6.3 Hypertension

Seven of the studies assessed the blood pressure of inmates but only four reported prevalence. All but one of the studies that reported hypertension prevalence found high rates among inmates (Fawad *et al.,* 2012; Gates and Bradford, 2015; Vera-Remartínez *et al.,* 2014). The minimum prevalence reported was 4% and the maximum was 21%. The overall mean reported by all studies was 12.6%. Fawad *et al.,* (2012) reported that as many as 34.3% of Pakistani prisoners had systolic pressure to be more than 140 mm Hg while the diastolic blood pressure for 61.4% was more than 90mm Hg. Kumar *et al.,* (2013) in contrast reported

a prevalence of 4% among Spanish inmates. The stress of prison environment and inability to have adequate sleep during the night contributes to this outcome (Alves *et al.,* 2015).

Blood pressure is another parameter that was positively associated with length of stay and inmates had an average increase of 4.81 mm Hg in systolic pressure and 4.38 mm Hg in diastolic pressure between the first and last quintile of incarceration. However, a drastic increase in blood pressure was observed for older entrants (Silverman-Retana *et al.,* 2015).

2.5.6.4 Dyslipidaemia

This is a risk factor assessed by five of the studies but only three reported its prevalence (Fawad *et al.,* 2012; Gates and Bradford, 2015; Vera-Remartínez *et al.,* 2014). Reported prevalence was 37.9%, 17% and 34.8% respectively. Data for the Gate and Bradford (2015) was extracted from an already existing electronic health record of offenders and this may have accounted for the relatively low prevalence reported.

Dyslipidaemia may be as a result of the effects of certain drugs such as antiretroviral drugs and psychotic medications (Fawad *et al.,* 2012; Gates and Bradford, 2015; Vera-Remartínez *et al.,* 2014). Inadequate fruit and vegetable intake as well as high intakes of saturated fat observed among study participants also predisposed inmates to dyslipidaemia (Collins and Thompson, 2012; Cook *et al.,* 2015; Fawad *et al.,* 2012).

2.5.6.5 Substance use

Nine studies reported on substance use. Smoking presents as one of the most common habits engaged in by prisoners (Bai *et al.,* 2015; Fawad *et al.,* 2012; Haysom *et al.,* 2013; Jaka *et al.,* 2014, Mukhtar *et al.,* 2013; Silverman-Retana *et al.,* 2015; Togas *et al.,* 2014; van Dooren *et al.,* 2013; Vera-Remartínez *et al.,* 2014). Prevalence of current smoking reported by studies were 64.1, 21.7, 51.1, 24.9, 88.0 and 70.4 respectively with an overall mean of 53.4. (Bai *et*

al., 2015; Fawad *et al.,* 2012; Haysom *et al.,* 2013; Jaka *et al.,* 2014; Mukhtar *et al.,* 2013; Togas *et al.,* 2014; van Dooren *et al.,* 2013; Vera-Remartínez *et al.,* 2014).

Three studies reported on past substance use and reported an overall prevalence of 72.8. Alcohol abuse and injection drug use were also reported by some studies (Silverman-Retana *et al.,* 2015; van Dooren *et al.,* 2013). Fawad *et al.,* (2012) found that 21.7% of prisoners smoked and 28.3% were addicted to other substances. This is consistent with what was found in other studies (Bai *et al.,* 2015; Haysom *et al.,* 2013; Jaka *et al.,* 2014; Mukhtar *et al.,* 2013; van Dooren *et al.,* 2013; Vera-Remartínez *et al.,* 2014).

Togas *et al.,* (2014) reported that 88% of inmates smoked and 68% of them were not ready to give up the act. Jaka *et al.,* (2014) reported a percentage of 59.1% and also found that smoking was associated with poorer self-perceived health status OR 1.76, 95% CI = 1.34-2.29). So were alcohol consumption and other drug use.

2.5.6.6 Physical activity

Four of the studies assessed physical activity levels of inmates and all found that most inmates were sedentary (Fawad *et al.,* 2012; Haysom *et al.,* 2013; Silverman-Retana *et al.,* 2015; Vera-Remartínez *et al.,* 2014). Prevalence of inactivity reported ranged from 38.5 to 71.7 with an overall mean of 57.4.

Female inmates are more likely to be sedentary compared to their male counterparts (Vera-Remartínez *et al.,* 2014). Fawad *et al.,* (2012) found that 25.9% of prisoners did nothing most of the time while Silverman-Retana *et al.,* (2015) reported that 37.9% had less than 30 minute of physical activity or were completely sedentary.

2.5.6.7 Diabetes

Seven of the studies reported on prevalence of diabetes (Alves *et al.,* 2015; Bai *et al.,* 2015; Fawad *et al.,* 2012; Gates and Bradford, 2015; Jaka *et al.,* 2014; Silverman-Retana *et al.,* 2015; Vera-Remartínez *et al.,* 2014; Wolff *et al.,* 2012). Prevalence rates reported by all studies were low and ranged from 1.58 to 5.3% (Silverman-Retana *et al.,* 2015; Vera-Remartínez *et al.,* 2014).

Occurrence of diabetes among prisoners has been linked to low fibre consumption as well as high intakes of refined foods (Collins and Thompson, 2012; Cook *et al.,* 2015). Positive weight changes leading to obesity also expose prisoners to diabetes (Bai *et al.,* 2015; Wolff *et al.,* 2012). Obesity was associated with increased risk of diabetes and cardiovascular conditions OR 3.16, 95% CI [1.56, 6.31] (Bai *et al.,* 2015). Also with diabetes, female inmates were found to be at a higher risk compared to males OR 2.49, 95% CI [1.17, 5.32] so were inmates above the age of forty OR 5.85, 95% CI [1.99-17.23] (Bai *et al.,* 2015), compared with those below.

2.5.7 Limitations of the systematic review

There are some limitations to this research work. First of all, data for most of the studies reviewed were collected in developed countries therefore results of the study may not be applicable to low income countries. None of the studies was undertaken in Ghana. Also most of the studies were cross sectional and did not assess cause and effect relationship but only looked at prevalence of these cardiovascular risk factors. The inaccessibility to full articles of some papers that met the inclusion criteria by title and abstract is also a limitation to the study.

2.6 A look at older prisoners

The use of the word older has generated lots of controversy with uncertainties as to which age bracket fit this category (Taylor and Yorston, 2006). In some studies individuals aged sixty (60) and above have been considered an older group while some studies have put individuals aged 40 and above within this same classification especially for the offending population (Fazel *et al*., 2001; Hayes *et al*., 2012). The use of a lower age range to predict older people may be helpful considering the upsurge in chronic diseases and the fact that they are beginning to occur earlier in life (Raitakari *et al*., 2008). The American Heart Association suggests that individuals aged forty and above should have a comprehensive risk assessment as a measure to prevent cardiovascular diseases (Pearson *et al*., 2002).

Older inmates are an increasing population worldwide (Harris *et al*., 2007; Loeb *et al*., 2014). This has been blamed on longer length of sentences, more stringency in dealing with present older offenders as compared to the past and an increase in life expectancy (Fazel *et al*., 2001; Hayes *et al*., 2012; Taylor and Yorston, 2006). Older inmates have greater health care needs in comparison with younger ones and their peers within the community (Williams *et al*., 2006). This prison population group is at a higher risk of chronic diseases and deteriorating physical health and pose a higher economic burden compared to the younger group (Maschi *et al*., 2012; Maschi *et al*., 2013). However, they are unlikely to receive differential care in terms of prisons' routines and are housed in buildings designed originally for younger individuals (Dawes, 2009; Le Mesurier, 2011). In a qualitative study by Loeb *et al.*, (2014), older inmates pleaded for access to better health care that they may die in dignity and not in pain.

Older prison inmates can be categorized into four groups; first time elderly prisoners which consist of notorious offenders being apprehended for their crimes for the first time; chronic offenders who are recidivist and as such return to prisons consistently, older individuals given

shorter sentences and lifers or those who have grown old within prisons (Aday, 2003). Adaptation of the prison environment as a home is more common to the latter group. This may be due to partial or complete loss of contact with family and a release from the prison poses huge challenge to this category of older inmates (Dawes, 2009).

High prevalence of chronic diseases among inmates especially older ones is a public health concern considering that approximately 95% of inmates are released and add to the numbers being taken care of by community health systems that are already overburdened (Ahalt *et al*., 2013). Inmates especially older ones have limited or no source of income prior to and post prison to address their health needs and are at a higher risk of death upon re-entry (Binswanger *et al*., 2007; Hopkins, 2012; Le Mesurier, 2011).

2.7 Institutional food Provision

Food provision within the institutional environment is important and goes beyond satisfying the physiological need for food to other matters such as cultural and family heritage which are of core importance to individuals (Godderis, 2006; Williams *et al*., 2006). The acquisition and consumption of food forms an integral part of prison life and is a unifier of inmates (Smoyer, 2014). Within institutionalized settings, a lot of time is spent on the preparation and serving of food and this can commence long lasting relationships (Kjaer Minke, 2014).

Over the years concerns have been raised on the low nutritional value of institutionalized meals especially within prisons where governments continue to cut down the cost of caring for inmates (Cabral and Saussier, 2013). Within the prison environment, pilfering of ingredients by inmates further worsens nutritional value of foods provided (Godderis, 2006; Reis *et al*., 2007; Smoyer, 2014). Prisons are of a particular concern when it comes to food provision because unlike other institutions, inmates are exposed to the food for relatively long

periods of time and foods from outside are either seldom or completely not allowed (Eves and Gesch, 2003).

Foods and drinks sold in institutionalized settings are mostly low in nutritional value and these go a step further to worsen institutional food provision (L'Abbé *et al*., 2013). Institutions are also places where a lot of food wastes occur (Williams *et al*., 2008; Williams *et al*., 2009). This has been linked to the low quality of foods served (Carpenter, 2006). Eves and Gesch (2003) found that the nutritional intakes of inmates are significantly less than what was provided by the kitchen. Several inexpensive ways can be adopted to improve institutionalized meals. Fortification of soups with soya beans and eggs is an example of inexpensive methods to improve the nutritional status of institutionally prepared meals (Donahue *et al*., 2015). In prisons, foods are mostly prepared by inmates and supervised by the kitchen staff (Williams *et al*., 2009).

Certain principles have been outlined as crucial in meal planning for both institutional and non-institutional consumption. These principles ensure continual selection of healthy food combinations. These include balance, variety, caloric control, moderation, adequacy and nutrient density (Rolfes *et al*., 2014). Nutrients should be in right proportions and enough to support health for the meal to be classified as balance and adequate respectively. The calories within the meal should not be excessive while providing all nutrients required to sustaining health. Varied sources should be relied on to provide nutrients and high fat and sugary foods should be seldom provided (Rolfes *et al*., 2014).

2.8 Nutrition and Behaviour

Reformation is the ultimate goal of incarceration. Optimal nutrition plays an important role in ensuring physical, mental and emotional health (Elmadfa and Meyer, 2010). Mental illness and aggression are the most prevalent health challenge been faced by inmates (Liu *et al*.,

2013; Meyer *et al*., 2015). This interferes with the reformation process and may make it difficult for prisoners to go through behaviour change programmes (Konrad, 2013). Additionally, certain nutrients have been implicated in responsible behaviour and inadequate intakes may worsen inmate behaviour and lead to high rates of reoffending (Parletta *et al*., 2013). Vitamin and mineral supplementation have been found to reduce aggressive behaviour but hypoglycaemia is strongly linked to aggressive episodes (Benton, 2007). Supplementation with vitamin B_{12} and folate alleviate symptoms of depression and subsequent aggression (Young, 2007). Adequacy of both macro and micronutrients is essential to maintaining and improving positive behaviour. Intervention through supplementation with magnesium, copper, zinc, vitamin B_6 and vitamin C among other vitamins and minerals reduce aggressive behaviour among inmates (Young, 2007).

Several neurotransmitters within the brain cells are made up of essential amino acids and deficiencies can result in or worsen aggressive behaviour (Rao *et al*., 2008). Essential fatty acids are vital for normal brain physiology and exhibit a positive association with non-violent behaviour (Meyer *et al*., 2015; Mihm, 2006). Iron is essential for the oxygenation of brain tissues and maintenance of brain integrity. Zinc is also protective against free radicals that cause brain damage and insufficient levels of magnesium is linked to brain degeneration (Rao *et al*., 2008).

Food is a basic human need and a determinant of behaviour. Prisoners like other individuals satisfy their basic need for food before paying attention to other activities that take place within the prison settings (Reid, 2016). Rehabilitation programmes will therefore go down the drain if they take place within an environment of nutrient and food scarcity (Carpenter, 2006).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Design

The study employed a cross sectional method that involved the assessment of metabolic syndrome parameters and their associated factors among older prisoners within the Kumasi metropolis. Data collection, involving both quantitative and qualitative data took place from the 6th October, 2016 to 17th October 2016.

3.2 Study population

Prison inmates either convicts or remands aged forty and above serving sentences at the Kumasi Central Prison, Kumasi Female Prison and Manhyia Local prison, all in the Ashanti Region of Ghana and were ‘’healthy’’ were used as the study population.

3.3 Study site

3.3.1 Ashanti Regional Command of Ghana Prisons Service

The Ashanti Regional Command of the Ghana Prisons Service consists of six prison establishments. The six prisons include a central prison, a female prison, two local prisons and two camp prisons. The Kumasi Central Prison is the regional command and has in its premise the regional commander. It oversees the activities of the other prisons within the region though the other prisons are independent in themselves (Ghana Prisons Service, 2012).

3.3.1.1 Kumasi Central Prisons

The Kumasi central prison is located in the heart of Kumasi and is the regional command for prisons in the Ashanti Region of Ghana. It is one of the seven central prisons within Ghana and the only central prison in the Ashanti Region of Ghana. It was established in the year

1901 by the British government for the punishment of offenders. It was however renovated in 1925 to cater for the increasing prison population. It covers an area of approximately 44,424 square feet and is located in Adum, behind the Wesley Methodist Cathedral in Kumasi. It houses only adult male prisoners aged 18 and above who have either been convicted or are on remand.

Over the years concerns have been raised about the location of the prison in the heart of Kumasi as it has been thought to facilitate prison break. Relocation of the Kumasi Central Prison has been proposed by the prisons service council and the ministry of interior in order to help with the expansion of the facility, improve inmates living conditions and address overcrowding which is a core challenge being faced by the facility. Though it was built to accommodate about six hundred (600) inmates, it currently has an inmate population of approximately one thousand seven hundred (1700). This has led to difficulty in the reformation of prisoners and the facility records high rates of recidivism. A current event on the effect of poor living conditions was the notorious attempt by prison inmates to break jail on the 4th of February, 2015. The prison has a number of workshops to help provide inmates with skills. Also within the facility is a kitchen and an infirmary for food provision and medical care respectively ("Regional commands," n.d., "Ashanti Regional Commands").

3.3.1.2 Manhyia Local Prisons

The Manhyia Local Prison is located in Kumasi, within the Manhyia palace which is the residence of the Ashanti King. The initial role of the prison was to incarcerate offenders who were found guilty by the Ashanti kingdom. The government of Ghana however took charge of the prison facility in 1954 and runs it as part of the local prisons in the country. It is one of the two local prisons located in the Ashanti Region of Ghana and the only local prison in Kumasi ("Regional commands," n.d., "Ashanti Regional Commands").

The prison covers a surface area of 0.001221km and it accommodates convict prisoners with relatively shorter length of sentence. It has six cells within which inmates are kept. The facility has an infirmary for treating minor ailments and a kitchen where food is provided to inmates (Ghana Prisons Service, 2012).

3.3.1.3 Kumasi Female Prison

The Kumasi Female prison used to be ran as part of the Kumasi Central Prisons but gained autonomy in the year 1991. This led to the prison manning its own affairs independently of the Kumasi Central Prison. It houses female offenders both remand and convicts. It forms part of the seven female prisons within Ghana and is the only female prison in Ashanti Region. It is also located in Adum Kumasi and is attached to the building of the Kumasi Central Prison. It covers 0.07 acres of land and has four cells that accommodate inmates.

It has within its premise a kitchen for the provision of food and a nurse who attends to the health care needs of inmates ("Regional commands," n.d., "Ashanti Regional Commands").

3.4 Sampling procedure

Random sampling was used to select inmates from the prison data base in three prisons in the Ashanti Region of Ghana. Ashanti region was chosen because it is the largest region in Ghana in terms of population size and houses six out of the total of forty five prisons in Ghana.

Inmates were sampled randomly from the prisons' database. The prisons included a central prison, a local prison and a female prison. This was done to enable comparisons to be made between the prisons and among male and female inmates. In Kumasi Central Prison a total list of one hundred and thirty seven (137) inmates was obtained, ten (10) from Kumasi Female Prison and nineteen (19) from Manhyia Local Prison. In total one hundred and sixty

six (166) inmates list was obtained. The research was explained in to details to inmates prior to the collection of data. In total one hundred and sixty (160) inmates met the inclusion criteria and gave their consent to participate in the study. Among this number were ten female prisoners. This number seems small but it is representative of female prison population considering the male to female convict ratio of 1: 58 (Ghana Prisons Service, 2012). All inmates excluded were from Kumasi Central. Prison wardens helped in the selection of participants for the study.

3.5 Sample size

The Cochran's formula was used to estimate the minimal sample size (Cochran, 1977). Below is the calculation;

Sample size = $Z_{1-\alpha/2}^2 p(1-p)/d^2$

$Z_{1-\alpha/2}^2$= 1.96 for confidence interval of 95%

p = Expected proportion in population based on previous reports is 0.11

d = absolute error of precision which taken as 0.05 for this study.

Sample size = $1.96^2 \times 0.11(1-0.11)/0.05^2$

Sample size = $3.8416 \times 0.11(0.89)/0.0025$

Sample size = 151

A sample size of one hundred and sixty was used for the study to make findings more applicable to the inmate population.

3.6 Data collection

Information obtained from participants was in six parts; demographic data, physical activity data, information on dietary intakes, current health status, past lifestyle, past dietary intakes and biochemical data. The questionnaire contained both closed ended and opened ended

questions and research assistants who had received prior training helped inmates through the questionnaire. This they did by reading the questions to inmates who agreed to participate in the study and ticking the options that match the responses given. Information on demographics covered age, gender, level of education, religion, previous occupation, length of sentence and length of stay. The part on physical activity levels looked at their involvement or otherwise in physical activity, kind of exercise they engaged in, frequency of exercises and time spent on exercises.

Data on past lifestyle, dietary intakes and activity levels covered information on smoking and alcohol intake status prior to incarceration, activity levels before imprisonment and foods usually consumed before imprisonment.

3.6.1 Dietary Assessment

This part focused on the number of meals inmates usually consumed in a day, foods eaten outside of the prison menu, frequency of foods eaten outside, the foods they normally consume outside the ones served in the prison, their frequency of intakes of fruits and vegetables and a 24 hour recall. The 24 hour recall involved the use of common household measures to estimate the quantity of foods eaten the previous day. Participants were asked to recall all the foods they had eaten the previous day and the times those foods were eaten. This was done to estimate the quantities of actual foods consumed by inmates though the household record gave a fair idea of food and nutrient provision.

- Measure 1 - 250 ml cup; this was used to estimate porridge and beverage intakes of study participants.
- Measure 2 - Medium Orange size; this was used to estimate intakes of banku, kenkey, rice balls, tuozaafi, kokonte and eba consumed by study participants.

- Measure 3 - Sardine tin; this was used to estimate quantities of bread and yam consumed by study participants.
- Measure 4 - Match box; this was used to estimate meat, fish and chicken intakes of participants.
- Measure 5 - Soup ladle; this was used to estimate the quantities of different kind of soups and porridges and vegetables consumed by participants.
- Measure 6 - Table spoon; this was used to estimate quantities of sugar, oil and milk consumption of participants.
- Measure 7 – Stew ladle; this was used to estimate quantities of stews and rice consumed by participants.

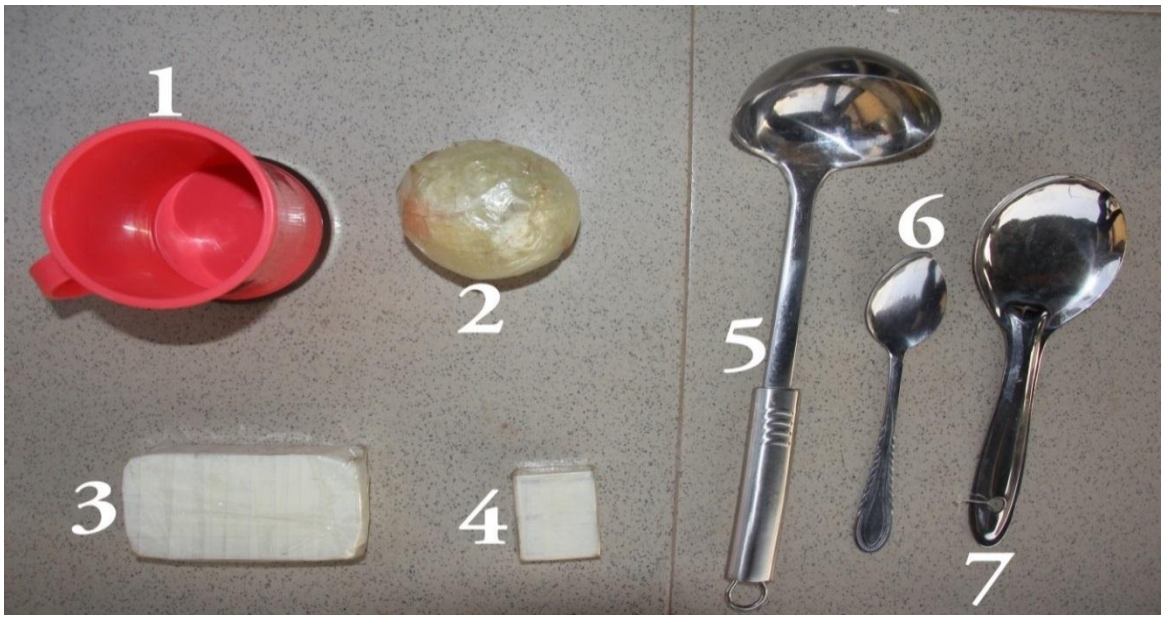

Plate 3.1: Household measures used in estimating food portions of participants

3.6.1.1 Household record

A three day household record was used to obtain information on usual dietary provision to participants. It was also used to ascertain if usual nutrient provision met the RDAs of inmates. It involved weighing for the three days; two weekdays and one weekend, all the

ingredients that were to be used for cooking. Food provision to participants was estimated by dividing the weights of the ingredients by the number of prisoners to be served. Nutrient intakes were calculated using Nutrient Analysis Template (University of Ghana, Food Science and Nutrition Department, 2010) and the West African Food Composition Table (Stadlmayr *et al.*, 2012). Individual foods were entered in grams into the nutrient analysis template to estimate quantities of nutrients.

3.6.2 Assessment of metabolic risk factors for Cardiovascular Diseases (CVDs)

Metabolic risk factors for CVDs were characterized by the components of the metabolic syndrome defined by the NCEP ATP III. These components include waist circumference, blood pressure, fasting blood glucose levels (FBG), HDL-c, and triglycerides (TG) (Haffner *et al.*, 2007). In addition to these criteria, Body Mass Index (BMI) of participants was calculated from their weights and heights to determine prevalence of overweight and obesity.

3.6.2.1 Anthropometric data

A plastic tape measure was used to measure the waist circumference of study participants to determine levels of central adiposity. Additionally the weight and height of the participants were taken and used to calculate their BMI.

3.6.2.2 Blood pressure

Systolic and diastolic blood pressure of study participants was taken twice using a digital sphygmomanometer (Omron, Japan). The latter reading was used for the analysis. This was used to classify participants as normotensive (< 120/80 mm Hg), pre hypertensive (120-139 mm Hg systolic and or diastolic 80-89 mm Hg) and hypertensive (> 140/90mm Hg).

3.6.2.3 Biochemical data

About 5ml fasting blood sample of all study participants was taken by a phlebotomist and analyzed for FBS and lipid profile. About 2mls of the sample taken was dispensed into a fluoride tube for glucose analysis and the remaining sample into an activator gel tube for the analysis of lipids. The blood samples were kept in an ice chest containing ice packs and transported to the clinical analysis laboratory of KNUST for the biochemical analysis. The samples for lipid profile analysis were centrifuged for ten minutes at a speed of 4000 rotation per minute (r.p.m) using the eppendorf centrifuge 5804 to obtain the serum for the analysis. Lipid profile and FBG were analyzed using the Randox rx monza semi-automated spectrophotometer.

3.6.2.3.1 Fasting Blood Glucose Analysis

The glucose oxidase – peroxidase method was employed in the blood glucose analysis.

Test principle

Glucose present in plasma is oxidized by the enzyme glucose oxidase to gluconic acid and hydrogen peroxide is given off in the process. The hydrogen peroxide is subsequently converted by peroxidase enzyme to water and oxygen. 4- aminoantipyrine, an oxygen acceptor takes up the oxygen and together with phenol forms a pink chromogen which is measured at 505nm.

$$\text{Glucose} + O_2 + H_2O \xrightarrow{\text{Glucose Oxidase}} \text{Gluconic acid} + H_2O_2$$

$$H_2O_2 + \text{Phenol} + \text{4 -aminoantipyrine} \xrightarrow{\text{Peroxidase}} \text{Red quinoneimine complex} + H_2O$$

Method

Into the test tubes labelled for the samples, 10 micro litre of the plasma of each sample was pipetted accordingly. Then 1ml of Liquidzone Glucose MR Reagent was pipetted into each of the test tubes. The test tube for the blank only contained the reagent. Each tube was swirled

gently to mix the reagent and the plasma sample thoroughly and incubated for 10 minutes in a water bath at 37 degrees Celsius. After incubation, the concentrations of each resulting sample and reagent mixture were read using the spectrophotometer with a 1cm light path cuvette at a wavelength of 505nm.

3.6.2.3.2 Triglycerides analysis

Triglyceride analysis was done using the GPO-PAP MONOLIQUID method. Enzymatic in vitro test was used for the quantitative determination of triglycerides.

Principle

Serum triglycerides are hydrolyzed to glycerol and free fatty acids by lipase. The glycerol component is phosphorylated in the presence of ATP and glycerol kinase (GK) to glycerol - 3- phosphate. Oxidation of glycerol- 3- phosphate by glycerol phosphate oxidase yields hydrogen peroxide. Hydrogen peroxide causes coupling of p- chlorophenol and 4 – aminoantipyrine by oxidation. This results in a red-coloured quinoneimine dye which is directly proportional to the triglyceride concentration of the sample when read at an absorbance of 520nm.

Triglycerides + H_2O $\xrightarrow{\text{Lipase}}$ glycerol + fatty acids

Glycerol + ATP $\xrightarrow{\text{GK, } Mg^{2+}}$ glycerol -1-phosphate + ADP

Glycerol - 1-phosphate + O_2 $\xrightarrow{\text{GPO}}$ H_2O_2+ dihydroxyacetone phosphate

H_2O_2 + 4- aminoantipyrine + p – chlorophenol $\xrightarrow{\text{Peroxidase}}$ 4- (p- benzoquinone-monoimino)- phenazone + $2H_2O$ + HCL

GK - glycerol kinase

GPO - glycerol phosphate oxidase

Method

Into each test tube, 10µl of serum sample was pipetted according to label. The blank had no serum sample. Then 1ml of the triglyceride reagent was added to the test tubes and mix thoroughly. They were then incubated in a water bath at 37 degrees Celsius for 5 minutes. Concentrations were read afterwards at a wavelength of 546nm.

3.6.2.3.3 Total cholesterol Analysis

Serum total cholesterol analysis was done using the CHOD-PAP method. Enzymatic in vitro test was used for the quantitative determination of total cholesterol.

Principle

Cholesterol is present in serum as cholesterol esters and free cholesterol. The cholesterol esters present in serum are hydrolysed by cholesterol esterase and the cholesterol is then measured by oxidizing with cholesterol oxidase to form hydrogen peroxide. The hydrogen peroxide in turn reacts with phenol and 4 – aminoantipyrine present to form red quinoneimine which is directly proportional to the amount of cholesterol present in the sample when read at an absorbance of 546nm.

Cholesterol Esters $\xrightarrow{CHE}$ Cholesterol + Fatty Acids

Cholesterol + O_2 $\xrightarrow{CHO}$ Cholesten – 3- one + H_2O_2

2 H_2O_2 + 4- aminoantipyrine + Phenol $\xrightarrow{Peroxidase}$ Quinoneimine + 4 H_2O

CHE- cholesterol esterase

CHO- cholesterol oxidase

Method

Into each test tube, 10µl of serum sample was pipetted according to label. The blank had no serum sample. Then 1ml of the total cholesterol reagent was added to the test tubes and

mixed thoroughly. They were then incubated in a water bath at 37 degrees Celsius for 5 minutes. Concentrations were read afterwards at a wavelength of 546 nm.

3.6.2.3.4 Serum HDL analysis

Addition of phosphotungstic acid in the presence of magnesium ions precipitates low density lipoprotein cholesterol. The HDL fraction retained in the supernatant is determined by cholesterol assay (Friedewald, 1972).

Method

The HDL precipitant was pre-diluted with distilled in the ratio 4:1. Thus, 400 microliters of the HDL precipitant was pipetted into the test tube and 100 microliters of distilled water was added and mixed. Then 200 microliters of serum was added and mixed well. This was made to stand for 10 minutes at room temperature. It was then centrifuged at 4000 r.p.m for 10 minutes. After centrifuging, a clear supernatant was obtained. Into new test tubes were 100 microliter of each supernatant pipetted and 1 ml of the Cholesterol CHOD-PAP reagent added. The test tubes were swirled to thoroughly mix the contents and incubated for 5 minutes at 37 degrees Celsius. Concentrations were read afterwards at a wavelength of 546nm.

3.6.2.3.5 Serum LDL analysis

Serum LDL was determined by the Friedewald equation:

LDL = Total cholesterol – HDL cholesterol – (triglycerides ÷ 2.2)

3.7 Inclusion criteria

Inmates aged forty and above who had been in prison for more than three months, who were fairly well and gave their consent were included in the study.

3.8 Exclusion criteria

Inmates below the ages of 40 as well as those who were critically ill were excluded from the study. Inmates who have been in the prison for less than three months were likewise excluded.

3.9 Data analysis

Data was entered into SPSS. Descriptive analysis was used to analyze the characteristics of study participants. SPSS software version 20.0 was used for the analysis of data. Student T-test was used to compare the means of parameters of the study. P-value of 0.05 was established as statistically significant. Correlational analysis was done between means of nutrient intakes and means of metabolic risk factors and used to determine the associations between nutrient intake levels and metabolic parameters. ANOVA and chi-square analysis were used to compare the three prisons.

3.10 Ethical consideration

Ethical clearance for the study was sought from the Committee on Human Research Publication and Ethics (CHRPE) of the School of Medical Sciences, KNUST, Kumasi. All participants of this study signed or thumb printed a consent form in accordance to the CHRPE regulations before taking part in the study. Additionally approval was sought and granted from the Ghana Prisons headquarters before data was collected from the different prison facilities.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

The results of this study are presented in this chapter. The outcome of this research is presented by means of frequency tables and bar charts.

4.2 Socio-demographic and incarceration characteristics of inmates

A total of one hundred and sixty (160) prisoners took part in the study. The Kumasi central prison had the highest number of participants (81.9%) followed by Manhyia local prison (11.9%) and Kumasi female prison (6.3%). Out of the total number, only 10 (6.3%) were females and the rest were males (93.8%). With respect to age distribution, 40.6% of the inmates were within the age range of 40-45, 22.5% within 46-50, 15.6% within 51-55, 6.9% within 56-60 and 14.4% were more than 60 years old. Basic education was the educational attainment of many of the inmates (53.1%) but a good percentage of them had no education (18.8%). Those who had secondary and tertiary education constituted 23.8% and 4.4% respectively. Majority of inmates were married (63.1%), 17.5% were divorced, 15% were single and 4.4% were widowed.

Most of the participants belonged to the Christian faith (76.3%), 20.6% were Muslims, two (1.3%) were traditionalist and three (1.9%) belonged to no particular faith. Prior to incarceration, 83.1% of inmates were engaged in low income jobs, 10.6% in middle income jobs and 6.3% in high paid jobs. Majority of prisoners (36.3%) had a sentence length within 1-10 years or 11-20 years (36.3%). Approximately 12% (11.9%) were given sentences between 21-30 years and three (1.9%) had a sentence length of 31-40 years. Life term and remand prisoners were 5% each. Majority of participants (37.5%) had been in the prison for more than five years, followed by those who had stayed for less than a year (25%), those

within 3-5 years of stay (20.6%) and those who had been in prison for 1-2 years (16.9%). Table 4.1 displays the demographic and incarceration characteristics of participants.

Table 4.1 Socio-demographics and Incarceration Characteristics of Participants.

Variable	Total n (%)	Kumasi central n (%)	Kumasi female n (%)	Manhyia local n (%)	P-value
Gender					
Male	150 (93.8)	131 (100)	0 (0)	19 (100)	
Female	10 (6.3)	0 (0)	10 (100)	0 (0)	
Age					
40-45 years	65 (40.6)	55 (42.0)	5 (50.0)	5 (26.3)	
46-50 years	36 (22.5)	28 (21.4)	3 (30.0)	5 (26.3)	0.143
51-55 years	25 (15.6)	16 (12.2)	2 (20.0)	7 (36.8)	
56-60 years	11 (6.9)	10 (7.6)	0 (0.0)	1 (5.3)	
>60 years	23 (14.4)	22 (16.8)	0 (0.0)	1 (5.3)	
Education					
None	30 (18.8)	27 (20.6)	1 (10.0)	2 (10.5)	
JHS	85 (53.1)	71 (54.2)	5 (50.0)	9 (47.4)	0.650
SHS	38 (23.8)	28 (21.4)	3 (30.0)	7 (36.8)	
Tertiary	7 (4.4)	5 (3.8)	1 (10.0)	1 (5.3)	
Marital status					
Single	24 (15)	22 (16.8)	1 (10.0)	1 (5.3)	
Married	101 (63.1)	83 (63.4)	5 (50.0)	13 68.4)	0.145
Divorced	28 (17.5)	21 (16.0)	2 (20.0)	5 (26.3)	
Widowed	7 (4.4)	5 (3.8)	2 (20.0)	0 (0.0)	
Religion					
Christian	122 (76.3)	98 (74.8)	7 (70.0)	17 (89.5)	
Muslim	33 (20.6)	28 (21.4)	3 (30.0)	2 (10.5)	0.805
Traditionalist	2 (1.3)	2 (1.5)	0 (0.0)	0 (0.0)	
None	3 (1.9)	3 (2.3)	0 (0.0)	0 (0.0)	
Previous occupation					
Low income	133 (83.1)	109 (83.2)	9 (90.0)	15 (78.9)	
Medium income	17 (10.6)	14 (10.7)	0 (0.0)	3 (15.8)	0.755
High income	10 (6.3)	8 (6.1)	1 (10.0)	1 (5.3)	
Length of sentence					
<1 year	6 (3.8)	2 (1.5)	1 (10.0)	3 (15.8)	
1-10 years	58 (36.2)	39 (29.8)	3 (30.0)	16 (84.2)	

11-20 years	58 (36.2)	57 (43.5)	1 (10.0)	0 (0.0)	0.000
21-30 years	19 (11.9)	19 (14.5)	0 (0.0)	0 (0.0)	
31-40 years	3 (1.9)	3 (2.3)	0 (0.0)	0 (0.0)	
Life imprisonment	8 (5.0)	8 (6.1)	0 (0.0)	0 (0.0)	
Remand	8 (5.0)	3 (2.3)	5 (50.0)	0 (0.0)	
Length of stay					
<1 year	40 (25.0)	27 (20.6)	7 (70.0)	6 (31.6)	
1-2 years	27 (16.9)	20 (15.3)	1 (10.0)	6 (31.6)	0.000
3-5 years	33 (20.6)	25 (19.1)	2 (20.0)	6 (31.6)	
>5 years	60 (37.5)	59 (45.0)	0 (0.0)	1 (5.3)	

Data is presented categorically in percentages and frequencies with percentages in parenthesis.

4.3 Past lifestyle behaviour of inmates

Table 4.2 shows the past lifestyle behaviour of participants prior to incarceration. Sixty nine (43.1%) out of the one hundred and sixty inmates included in the study smoked and 56.9% were non-smokers. Those who drank alcohol prior to incarceration represented 48.8% however majority of inmates (51.2%) did not take in alcohol prior to incarceration. A good proportion of study participants (45%) were physically active prior to incarceration. Those who were sedentary constituted the least percentage (13.8%). Those who were moderately active and those who were very active made up 25% and 16.2% of inmates respectively.

Table 4.2 Past lifestyle behaviour of the participants

Variable	**Total n (%)**	**Kumasi central n (%)**	**Kumasi female n (%)**	**Manhyia local n (%)**	**P-value**
Past smoking					
Yes	69 (43.1)	62 (47.3)	0 (0.0)	7 (36.8)	0.012
No	91 (56.9)	69 (52.7)	10 (100)	12 (63.2)	
Past alcohol intake					
Yes	78 (48.8)	61 (46.6)	4 (40.0)	13 (68.4)	0.174
No	82 (51.2)	70 (53.4)	6 (60.0)	6 (31.6)	
Past activity levels					

Very active	26 (16.2)	24 (18.3)	0 (0.0)	2 (10.5)	0.057
Moderately active	40 (25.0)	36 (27.5)	2 (20.0)	2 (10.5)	
Active	72 (45.0)	51 (38.9)	8 (80.0)	13 (68.4)	
Sedentary	22 (13.8)	20 (15.3)	0 (0.0)	2 (10.5)	

Data is presented categorically in percentages and frequencies with percentages in parenthesis.

4.4 Average daily Nutrient Provision within the Prisons

Table 4.3 presents the average daily nutrient provision within the three prisons in comparison with RDA, AI or AMDR of the nutrients. The overall daily caloric provision for the Kumasi central, Kumasi female and Manhyia local prisons were 2021.7kcal/d, 3383kcal/d and 2083.1kcal/d respectively with an overall mean of 2114.1kcal/d for all three prisons. Daily average protein provision represented 6.8%/d, 28.2%/d and 8.1%/d of total calories provided in the Kumasi central prison, Kumasi female prison and Manhyia local prison respectively. The overall mean protein percentage was 8.3%/d. The overall carbohydrate percentage mean was 70.3%/d and individually 73.8%/d, 35.8%/d, 68%/d for Kumasi central, Kumasi female and Manhyia local prisons respectively. Fat covered 26.3%/d of calories provided by the Kumasi central prison, 35.9%/d of that provided by Kumasi female prison and 27.7%/d of calories supplied by the Manhyia local Prison with 27.1%/d as the overall mean.

Fibre provided were 28g/d, 42.4g/d and 21.6g/d for the Kumasi central, Kumasi female and Manhyia local accordingly with a total mean of 28.1g/d. Overall potassium mean was 1452.8mg/d and supply was 1232.2mg/d, 3576mg/d, and 1856mg/d for the Kumasi central, Kumasi female and Manhyia local prisons respectively. Overall average sodium provided was 1496mg/d, 1031.1mg/d for the Kumasi central, 3939.4mg/d for the Kumasi female and 3415.6mg/d for Manhyia local.

The total average Vitamin E provided for all three prisons was 3.2mg/d with the Kumasi central, Kumasi female and Manhyia local prisons recording mean supply of 1.4mg/d, 18.5mg/d and 7.9mg/d correspondingly. The total average of vitamin C provided was

28.1mg/d with 15mg/d, 96.4mg/d and 24.8mg/d provided individually by the Kumasi central, Kumasi female and Manhyia local respectively. Vitamin B_{12} accounted for 0.1µg/d, 2.8µg/d and 1.8µg/d of nutrients provided accordingly by the Kumasi central, Kumasi female and Manhyia local prisons with a total mean of 0.47µg/d. The Kumasi central, Kumasi female and Manhyia local prisons provided 1.4mg/d, 2.9mg/d and 2.0mg/d of vitamin B_6 respectively with a total mean of 1.6mg/d. Folate provided in the Kumasi central, Kumasi female and Manhyia prisons was 136.6µg/d, 868.3µg/d and 332µg/d accordingly with an overall average of 205.5µg/d.

Iron supplied was 13.6mg/d, 23.6mg/d and 13.2mg/d in the Kumasi central, Kumasi female and Manhyia local prisons with a total mean of 14.2mg/d. Zinc constituted 7.2mg/d, 16.8mg/d and 8.2mg/d of nutrients provided by the Kumasi central, Kumasi female and Manhyia local respectively. Overall mean of zinc provided was 7.9mg/d.

Table 4.3 Average nutrient provisions within the prisons

Nutrient	AMDR/RDA/AI	SUPPLY			Overall mean	% RDA			P-value
		Kumasi central	Kumasi female	Manhyia local		Kumasi central	Kumasi female	Manhyia local	
Energy (Kcal/d)	1800 for males and 1670 for females	2021.7[a]	3383.0[b]	2083.1[c]	2114.1± 329.3	112.3% Excess	202.6% Excess	115.7% Excess	0.00
Protein (%AMDR/d)	10-35%	6.8[a]	28.2[b]	8.1[c]	8.3±5.2	Inadequate	Adequate	Inadequate	0.00
Carbohydrate (%AMDR/d)	45-65%	73.8[a]	35.8[b]	68[c]	70.3±11.1	Excess	Inadequate	Excess	0.00
Fat (%AMDR/d)	20-35%	26.3[a]	35.9[b]	27.7[c]	27.1±2.3	Adequate	Excess	Adequate	0.00
Fibre(g/d)	38g/d for men and 25g for women	28.0[a]	42.4[b]	21.6[c]	28.1±4.2	73.7% (Inadequate)	170% (Excess)	56.8% (Inadequate)	0.00
Potassium (mg/d)	4700mg/d	1232.2[a]	3576.0[b]	1856.0[c]	1452.8± 585.7	26.2% (Inadequate)	76.1% (Inadequate)	39.5% (Inadequate)	0.00
Sodium (mg/d)	1500mg/d	1031.1[a]	3939.4[b]	3415.6[c]	1496.0± 996.9	68.7% (Adequate)	262.6% (Excess)	227.7% (Excess)	0.00
Vitamin E (mg/d)	15mg/d	1.4[a]	18.5[b]	7.9[c]	3.2±4.5	9.3% (Inadequate)	123.3% (Excess)	52.7% (Inadequate)	0.00
Vitamin C (mg/d)	90mg/d for men 75mg/d for women	15.0[a]	96.4[b]	24.8[c]	28.1±18.0	16.7% (Inadequate)	128.5% (Excess)	27.6% (Inadequate)	0.00

Vitamin B_{12} (µg/d)	2.4µg/d	0.1 [a]	2.8[b]	1.8[c]	0.47±0.8	3.8% (Inadequate)	116.7% (Excess)	75% (Inadequate)	0.00
Vitamin B_6 (mg/d)	1.3mg/d	1.4[a]	2.9[b]	2.0[c]	1.6±0.4	107.7% (Adequate)	223.1% (Excess)	153.8% (Excess)	0.00
Folate (µg/d)	400µg/d	136.6[a]	868.3[b]	332.0[c]	205.5± 182.9	34.2 % (Inadequate)	217% (Excess)	83% (Inadequate)	0.00
Iron (mg/d)	8mg/d for men and 18mg/d for women	13.6[a]	23.6[b]	13.2[c]	13.2±2.4	170% (Excess)	131.1% (Excess)	165% (Excess)	0.00
Zinc (mg/d)	11mg/d for men and 8mg/d for women	7.2[a]	16.8[b]	8.2[c]	7.9±2.3	65.5% (Inadequate)	210% (Excess)	74.5% (Inadequate)	0.00

Macronutrients are presented in percentages of total caloric contribution. Micronutrients are presented in milligrams per day (mg/d) or micrograms per day (µg/d). The overall mean represents the mean of the three prisons. Statistical differences exist in all nutrient provision among the three prisons at 95% confidence interval. [abc]Posthoc analysis shows that means of nutrient provisions are significantly different from each other.

4.5 Actual Nutrient intakes of inmates

Table 4.4 displays the actual nutrient intakes of inmates as against the RDA, AMDR or AI of the nutrients. The overall mean energy consumed was 1268.5±613.4kcal/d and 1288±649.2kcal/d for the Kumasi central, 1259±343.7kcal/d for the Kumasi female and 1136±445.4kcal/d for the Manhyia local prison. The mean percentage protein intake for Kumasi central was 8.6±2.8%/d, 10.5±2.6%/d for the Kumasi female and 8.5±1.6%/d for Manhyia local. The overall mean of protein intake for all inmates was 8.7±2.7%/d. The overall mean of fat intake was 19.8±8.0%/d. The mean fat intake percentage for Kumasi central, Kumasi female and Manhyia local were 19.3±8.1%/d, 22.8±6.2%/d and 21.8±8.2%/d respectively. Average carbohydrate intake was 72.1±8.7%/d, 66.7±7.9%/d and 69.7±8.3%/d for the Kumasi central, Kumasi female and Manhyia local prisons correspondingly. The overall mean was 71.5±8.7%/d.

The mean fibre intake for the Kumasi central, Kumasi female and Manhyia local was 20.6±11g/d, 20.9±5.9g/d and 16.9±6.5g/d respectively with an overall average intake of 20.2±10.4g/d. Average potassium intake in the Kumasi central prison was 1451.6±873.4mg/d, that of Kumasi female and Manhyia local were1824.4±596.6mg/d and 1162.7±535.2mg/d accordingly. The overall potassium intake was 1440.6±833.6mg/d. Mean sodium intakes for the Kumasi central, Kumasi female and Manhyia local were 2470.5±1286.5mg/d, 2074.7±860mg/d and 2086.1±704.5mg/d respectively. The total average sodium intake was 2400.1±1214.0mg/d.

The average total vitamin E intake was 11±97.2mg/d. The Kumasi central, Kumasi female and Manhyia local prison had mean vitamin E intakes of 12.4±107.4mg/d, 5.2±2.5mg/d and 4.1±2.9mg/d correspondingly. The mean intake of all inmates was 207.5±232.9µg/d. Average vitamin C intake was 53.7±42.7mg/d for the Kumasi central prison, 63.3±28.7mg/d for the

Kumasi female prison and 44.4±25.8mg/d for the Manhyia local prison. The overall mean intake for vitamin C was 53.2±40.4mg/d.

The mean intakes of vitamin B_6 were 1.2±0.7mg/d, 1.2±0.3mg/d and 1.4±0.9mg/d for the Kumasi central, Kumasi female and Manhyia local prisons respectively and a total mean of 1.2±0.7mg/d for the three prisons. Mean folate intakes were 182.4±204.7µg/d, 398±320.1µg/d and 280.5±308µg/d for the Kumasi central, Kumasi female and Manhyia local prisons respectively. The average vitamin B_{12} intakes were 1.0±3.2µg/d, 0.7±1.5µg/d and 1.6±3.7µg/d for the Kumasi central, Kumasi female and Manhyia local accordingly with 1.0±3.2µg/d as the mean total intake for all inmates.

Mean iron intakes were 8.4±4.7mg/d, 9.5±3.7mg/d and 8.0±5.0mg/d for the Kumasi central, Kumasi female and Manhyia local prisons. The average total mean for iron was 8.4±4.7mg/d for all three prisons. The mean of zinc intakes were 5.3±3.2mg/d, 5.8±2.1mg/d and 5.7±4.1mg/d for the Kumasi central, Kumasi female and Manhyia local prisons respectively with a total mean 5.4±3.2mg/d.

Table 4.4 Actual nutrient intakes of inmates

Nutrient	RDA/AI	Actual Intakes			Overall mean	% RDA			P-value
		Kumasi central	Kumasi female	Manhyia local		Kumasi central	Kumasi female	Manhyia local	
Energy (Kcal/d)	1800 kcal for males and 1670 for females	1288±649.2	1259±343.7	1136±445.4	1268.5±613.4	71.6% Inadequate	75.3.9% Inadequate	63.1% Inadequate	0.601
Protein (%AMDR/d)	(10-35%)	8.6±2.8	10.5±2.6	8.5±1.6	8.7±2.7	Inadequate	Adequate	Inadequate	0.088
Carbohydrate (%AMDR/d)	(45-65%)	72.1±8.7	66.7±7.9	69.7±8.3	71.5±8.7	Excess	Excess	Excess	0.101
Fat (%AMDR/d)	(20-35%)	19.3±8.1	22.8±6.2	21.8±8.2	19.8±8.0	Adequate	Adequate	Adequate	0.219
Fibre(g/d)	38g/d for men and 25g for women	20.6±11	20.9±5.9	16.9±6.5	20.2±10.4	54.2% (Inadequate)	83.6% (Inadequate)	44.5% (Inadequate)	0.348
Potassium (mg/d)	4700mg/d	1451.6±873.4	1824.4±596.6	1162.7±535.2	1440.6±833.6	30.9% (Inadequate)	38.8% (Inadequate)	24.7% (Inadequate)	0.119
Sodium (mg/d)	1500mg/d	2470.5±1286.5	2074.7±860	2086.1±704.5	2400.1±1214.0	164.7% (Excess)	138.3% (Excess)	139.1% (Excess)	0.299
Vitamin E (mg/d)	15mg/d	3.0±2.9	5.2±2.5	4.1±2.9	3.3±3.0	82.6% (Inadequate)	34.7% (Inadequate)	20% (Inadequate)	0.033
Vitamin C (mg/d)	90mg/d for men 75mg/d for women	53.7 ±42.7)	63.3±28.7	44.4±25.8	53.2±40.4	59.7%% (Inadequate)	84.4% (Inadequate)	49.3% (Inadequate)	0.466
Vitamin B_{12} (µg/d)	2.4µg/d	1.0±3.2	0.7±1.5	1.6±3.7	1.0±3.2	41.7% (Inadequate)	29.2% (Inadequate)	66.7% (Inadequate)	0.667
Vitamin B_6 (mg/d)	1.3mg/d	1.2±0.7	1.2±0.3	1.4±0.9	1.2±0.7	92.3% (Inadequate)	92.3% (Inadequate)	109.7% (Adequate)	0.618
Folate (µg/d)	400µg/d	182.4±204.7[a]	398.2±320.1[b]	280.5±308	207.5±232.9	45.6% (Inadequate)	99.6% (Adequate)	70.1% (Inadequate)	0.006

Iron (mg/d)	8mg/d for men and 18mg/d for women	8.4±4.7	9.5±3.7	8.0±5.0	8.4±4.7	105% (Adequate)	52.8% (Inadequate)	100% (Adequate)	0.711
Zinc (mg/d)	11mg/d for men and 8mg/d for women	5.3±3.2	5.8±2.1	5.7±4.1	5.4±3.2	48.2% (Inadequate)	72.5% (Inadequate)	51.8% (Inadequate)	0.829

Data on nutrient intakes is from a 24-hour recall. Difference in actual intakes for all nutrients with the exception of folate and vitamin E is statistically not significant among the three prisons at 95% confidence interval. [ab]Posthoc analysis shows that differences in folate intake exist between the Kumasi central and Kumasi female Prison

4.6 Differences between nutrient supply and actual nutrient intakes

Table 4.5 shows the differences between nutrient supply and actual intakes. All prisons had a lower caloric intake than what was provided, -733.7kcal for the Kumasi central, -2124kcal for the Kumasi female and -947.1kcal for the Manhyia local. The Kumasi central and Manhyia local prisons had a positive intake with regards to protein with intake being greater than supply; +1.8%, and +0.4% respectively. The Kumasi female prison however had a lower intake compared to supply (-17.7%). Carbohydrate intake was lower than supply for the Kumasi central prison (-1.7%) but intake for the Kumasi female and Manhyia local prisons was higher than supply; +30.9%, +1.7% correspondingly. Fat intake was lower than supply for all prisons, -7%, -13.1% and -5.9% for the Kumasi central, Kumasi female and Manhyia local prisons respectively.

Fibre intake was likewise lower than supply for all three prisons, -7.4g, -21.5g, and 4.7g for the Kumasi central, Kumasi female and Manhyia local prison respectively. Differences between potassium intake and supply was positive for the Kumasi central prison +219.4mg but negative for the Kumasi female (-1751.6mg) and Manhyia local prisons (-693.3mg). Inmates from the Kumasi central prison had their mean sodium intake to be more than sodium supplied. Inmates from Kumasi female and Manhyia local however had a lesser intake compared to supply, -1864.7mg and -1329.5mg respectively.

Vitamin E intake was less than supply for the Kumasi female (-13.3mg) and Manhyia local prisons (-3.8mg) but inmates at the Kumasi central prison had an intake level that was more than supply (+1.6mg). Vitamin C intakes for both Kumasi central and Manhyia local were more than quantities supplied within the prisons, +38.7mg and +19.6mg correspondingly. Inmates from the Kumasi female prisons had an intake level that was less than quantity provided (-33.1mg).

Intake of vitamin B_{12} in the Kumasi central prison was greater than supply +0.91µg, while intake in Kumasi female was less than supply -2.1µg with intake at Manhyia local prison being slightly lower than supply (-0.2µg). Intakes of vitamin B_6 was less than supply for the Kumasi central prison (-0.2mg) and Kumasi female prison (-1.7mg). Inmates at the Manhyia local prison however had a positive intake level (+0.6mg). Folate intake was greater than supply only for the Kumasi central prison (+45.8µg) but negative for the Kumasi female (-470.1µg) and Manhyia local prisons (-51.5µg).

Iron intake was negative for all prisons, -1.9mg for Kumasi central, -11mg for the Kumasi female and -2.5mg for the Manhyia local prison. Zinc intake was also negative for all prison, -1.9 for the Kumasi central, -11 for the Kumasi female and -2.5 for the Manhyia local prison.

Table 4.5 Differences between actual intakes and supply

NUTRIENT	SUPPLY			ACTUAL INTAKES			DISPARITY		
	Kumasi central	Kumasi female	Manhyia local	Kumasi central	Kumasi female	Manhyia local	Kumasi central	Kumasi female	Manhyia local
Energy (Kcal/d)	2021.7	3383.0	2083.1	1288±649.2	1259±343.7	1136±445.4	-733.7	-947.1	-2124
Protein (%AMDR/d)	6.8	28.2	8.1	8.6±2.8	10.5±2.6	8.5±1.6	+1.8%	+0.4%	-17.7%
Carbohydrate (%AMDR/d)	73.8	35.8	68	72.1±8.7	66.7±7.9	69.7±8.3	-1.7%	+1.7%	+30.9%
Fat (%AMDR/d)	26.3	35.9	27.7	19.3±8.1	22.8±6.2	21.8±8.2	-7	-5.9	-13.1
Fibre(g/d)	28.0	42.4	21.6	20.6±11	20.9±5.9	16.9±6.5	-7.4	-4.7	-21.5
Potassium (mg/d)	1232.2	3576.0	1856.0	1451.6±873.4	1824.4±596.6	1162.7±535.2	+219.4	-693.3	-1751.6
Sodium (mg/d)	1031.1	3939.4	3415.6	2470.5±1286.5	2074.7±860	2086.1±704.5	+1439.4	-1329.5	-1864.7
Vitamin E (mg/d)	1.4	18.5	7.9	3.0±2.9	5.2±2.5	4.1±2.9	+1.6	-3.8	-13.3
Vitamin C(mg/d)	15.0	96.4	24.8	53.7 ±42.7)	63.3±28.7	44.4±25.8	+38.7	+19.6	-33.1
Vitamin B_{12} (µg/d)	0.09	2.8	1.8	1.0±3.2	0.7±1.5	1.6±3.7	+0.91	-0.2	-2.1
Vitamin B_6 (mg/d)	1.4	2.9	2.0	1.2±0.7	1.2±0.3	1.4±0.9	-0.2	+0.6	-1.7
Folate (µg/d)	136.6	868.3	332.0	182.4±204.7	398.2±320.1	280.5±308	+45.8	-51.5	-470.1
Iron (mg/d)	13.6	23.6	13.2	8.4±4.7	9.5±3.7	8.0±5.0	-5.2	-5.2	-14.1
Zinc (mg/d)	7.2	16.8	8.2	5.3±3.2	5.8±2.1	5.7±4.1	-1.9	-2.5	-11

Differences in nutrient intakes and actual intake are calculated by subtracting actual intakes from nutrients supplied. (-) denotes an intake level that is less than more supply while (+) denotes an intake level that is more than supply.

4.7 Dietary patterns of Inmates

Table 4.6 displays the dietary patterns of inmates. Majority of inmates mostly ate twice a day (69.4%), followed by those who ate thrice daily (20.6%) and once a day (10%). A high percentage of inmates consumed foods outside of the prison menu (73.1%), and 26.9% solely depended on prison foods.

Those who consumed foods from outside in addition to the prison menu occasionally constituted 25% of inmates followed by those who consumed outside foods on a weekly basis (21.9%). Twenty five (15.6%) inmates consumed outside foods on monthly basis and seventeen (10.6%) ate outside a daily basis. Foods consumed by most inmates (70.0%) outside the menu were devoid of fruits and vegetables. Two (1.2%) consumed fruits and vegetables and only one (0.6%) consumed foods from all the food groups. One (0.6%) consumed carbohydrate foods and only one (0.6%) also consumed carbohydrate and fatty foods.

Table 4.6 Dietary Patterns of Inmates

Variable	Total n(%)	Kumasi central n(%)	Kumasi female n(%)	Manhyia local n(%)	P-value
Foods eaten outside menu					
Yes	117(73.1)	94(71.8)	8(80)	15(78.9)	0.752
No	43(26.9)	37(28.2)	2(20)	4(21.1)	
Frequency of foods eating outside					
Daily	17(10.6)	14(10.7)	0(0)	3(15.8)	0.137
Weekly	35(21.9)	29(22.1)	5(50)	1(5.3)	
Monthly	25(15.6)	19(14.5)	0(0)	6(31.6)	
Occasionally	40(25)	32(24.4)	3(30)	5(26.3)	
Food groups eaten outside					
None	43(26.9)	37(28.2)	2(20)	4(21.1)	
Carbohydrates	1(0.6)	1(0.8)	0(0)	0(0)	0.527
Carbohydrates and fats	1(0.6)	1(0.8)	0(0)	0(0)	
>2 food groups with little or no fruits and vegetables	112(70.0)	90(68.7)	7(70)	15(78.9)	
>2 foods groups with fruits and vegetables	2(1.2)	1(0.8)	1(10)	0(0)	
All food groups	1(0.6)	1(0.8)	0(0)	0(0)	
Number of meals daily					
Once	16(10)	16(12.2)	0(0)	0(0)	
Twice	111(69.4)	96(73.3)	0(0)	15(78.9)	0.000
Thrice	33(20.6)	19(14.5)	10(100)	4(21.1)	
Fruits and vegetable intake					
Daily	3(1.9)	3(2.3)	0(0)	0(0)	
Weekly	10(6.2)	9(6.9)	1(10)	0(0)	0.908
Monthly	9(5.6)	8(6.1)	0(0)	1(5.3)	
Occasionally	84(52.5)	67(51.1)	5(50)	12(63.2)	
Never	54(33.8)	44(33.6)	4(40)	6(31.6)	

Categorical data is presented in frequencies and percentages with percentages in parenthesis. Statistical differences exist with respect to number of meals eaten per day among the prisons at 95% confidence interval.

4.7.1 Differences in nutrient intake among inmates who eat outside the prison menu and those who solely depend on prison foods.

Table 4.7 shows differences in nutrient intakes among inmates who eat outside the prison menu and those who consume only foods provided in the prison. Those who eat outside the prison menu had higher intakes for all nutrients but the differences observed were not statistically significant except for potassium.

Table 4.7 Differences in nutrient intakes among inmates who eat outside the prison menu and those who solely depend on prison foods.

Nutrient intakes	Mean intakes		P-value
	Eat outside prison menu n=117	No foods outside prison menu n=43	
Energy (Kcal/d)	1289.5±636.3	1209.7±546.7	0.439
Protein (% AMDR/d)	8.4±5.4	7.9±4.6	0.586
Carbohydrate (% AMDR/d)	70.0±11.5	71.1±9.9	0.552
Fat (% AMDR/d)	27.1±2.4	26.9±2.1	0.489
Fibre (g/d)	20.5±10.8	19.3±9.2	0.497
Potassium (mg/d)	1528.7±882.3	1193.2±622.9	0.009*
Sodium (mg/d)	2404.5±1206.4	2387.73±1249.6	0.940
Vitamin E (mg/d)	3.4±3.1	2.9±2.5	0.212
Vitamin C (mg/d)	54.2±43.7	50.267±29.5	0.516
Vitamin B12 (µg/d)	1.2±3.5	0.6±2.1	0.232
Vitamin B6 (mg/d)	1.2±0.7	1.2±0.7	0.718
Folate (µg/d)	216.4±236.5	182.5±223.5	0.409
Iron (mg/d)	8.6±4.8	7.9±4.5	0.456
Zinc (mg/d)	5.6±3.3	5.1±3.0	0.374

Differences in nutrient intakes among inmates who eat outside the prison menu and those who solely depend on prison foods. *Differences observed between mean intakes are statistically significant.

4.8 Metabolic Characteristics of Study Participants

Table 4.7a and Table 4.7b summarize the metabolic characteristics of study participants. The mean systolic and diastolic blood pressure of all study participants was 141.1±23.2mm Hg and 88.9±14mm Hg respectively. Mean systolic blood pressure was 139.3±23.4mm Hg,

149.3±11.4 mm Hg and 149.4±25 mm Hg for the Kumasi central, Kumasi female and Manhyia local prisons respectively. The mean diastolic blood pressure was 88.3±14.3 mm Hg for the Kumasi central, 96.7±9.0 mm Hg for the Kumasi female and 89.5±13.4 mm Hg for the Manhyia local prison.

The mean BMI for Kumasi central was 22.7±3.9kg/m^2, 26.9±5.5 kg/m^2 for Kumasi female, and 20.9±2.4 kg/m^2 for the Manhyia local prison. Mean BMI and waist circumference were 22.8±4.1 kg/m^2 and 81.1±10.3cm respectively for all participants. Mean waist circumference was 81.4±10.4cm for the Kumasi central, 83.2±13.2cm for the Kumasi female and 78.1±7.7cm for the Manhyia local prisons.

The average fasting blood glucose for all participants was 4.3±0.9 mmol/L. Inmates at the Kumasi central prison had an average FBS of 4.3±0.9 mmol/L with those at the Kumasi female and Manhyia local having a mean FBS of 5.0±0.9mmol/L and 4.2±0.8 mmol/L respectively.

The mean HDL for all participants was 1.4±0.4 mmol/L and individually 1.4±0.4 mmol/L, 1.4±0.2 mmol/L and 1.3±0.3 mmol/L for the Kumasi central, Kumasi female and Manhyia local prison correspondingly. Mean LDL for the Kumasi central prison was 3.0±1 mmol/L, 3.4±0.8 mmol/L for the Kumasi female and 2.5±1 mmol/L for the Manhyia local prison and an overall mean of 3.0±1.0 mmol/L. Average triglyceride level was 1.1±0.6 mmol/L and average total cholesterol was 4.9±1.3 mmol/L for all participants. Inmates at the Kumasi central prison had an average triglyceride level of 1.2±0.7 mmol/L, 0.9±0.3 mmol/L for the Kumasi female and 0.8±0.4 mmol/L for the Manhyia local prison. Mean total cholesterol was 5.0±1.3 mmol/L, 5.2±1 mmol/L and 4.2±1.2 mmol/L for the Kumasi central, Kumasi female and Manhyia local prison respectively.

Table 4.7a Metabolic Characteristics of Study Participants

Parameter	Mean ± SD	Gender		P-value	Age					P-value
		Male	Female		40-45	46-50	51-55	56-60	>60	
BMI (kg/m^2)	22.8±4.1	22.5±3.8	26.9±5.5	0.032*	22.3±3.2	23.3±5.0	22.8±4.8	21.6±4.2	23.7±3.9	0.504
Systolic (mm Hg)	141.1±23.2	140.5±23.7	149.3±11.4	0.050*	132±19.3	142±23.3	146.7±21.6	159.8±29.3	149.9±22.6	0.000*
Diastolic (mm Hg)	88.9±14	88.4±14.2	96.7±9.0	0.019*	85.1±14.6	89.1±13.5	90.4±11	102.8±16.3	91.3±10.3	0.002*
FBS (mmol/L)	4.3±0.9	4.3±0.9	5.0±0.9	0.038*	4.1±0.6	4.4±1.2	4.6±0.8	4.4±0.6	4.5±0.9	0.147
HDL (mmol/L)	1.4±0.4	1.4±0.4	1.4±0.2	0.821	1.4±0.3	1.4±0.4	1.4±0.4	1.5±0.4	1.4±0.4	0.643
LDL (mmol/L)	3.0±1.0	2.9±1.0	3.4±0.8	0.151	2.8±1.0	3.0±1.1	3.0±0.9	3.7±0.8	3.1±1.0	0.106
Tg(mmol/L)	1.1±0.6	1.1±0.7	0.9±0.3	0.045*	1.0±0.5	1.2±0.8	1.3±0.8	1±0.4	1.2±0.7	0.324
Total Cholesterol (mmol/L)	4.9±1.3	4.9±1.3	5.2±1.0	0.421	4.6±1.2	5.0±1.5	5.0±1.3	5.7±1.1	5.1±1.3	0.114
Waist Circumference (cm)	81.1±10.3	81.0±10.1	83.2±13.2	0.613	79.1	82.2±13.3	81.9±10.7	77.0±7.9	86.2±9.6	0.033*

Means of parameters are presented by gender and age. *Statistical differences exist between means of parameters among categories at $p \leq 0.05$.

Table 4.7b Metabolic Characteristics of Study Participants

Parameter	Prison			P-value
	Kumasi central	Kumasi Female	Manhyia local	
BMI (kg/m^2)	22.7±3.9	26.9±5.5	20.9±2.4	0.001
Systolic (mm Hg)	139.3±23.4	149.3±1.4	149.4±25	0.110
Diastolic (mm Hg)	88.3±14.3	96.7±9.0	89.5±13.4	0.184
FBS (mmol/L)	4.3±0.9	5.0±0.9	4.2±0.8	0.43
HDL (mmol/L)	1.4±0.4	1.4±0.2	1.3±0.3	0.290
LDL (mmol/L)	3.0±1.0	3.4±0.8	2.5±1	0.055
Tg(mmol/L)	1.2±0.7	0.9±0.3	0.8±0.4	0.025*
Total Cholesterol (mmol/L)	5.0±1.3	5.2±1.0	4.2±1.2	0.024*
Waist Circumference (cm)	81.4±10.4	83.2±13.2	78.1±7.7	0.349

Means of parameters are presented by prison. *Statistical differences exist between means of parameters at $p \leq 0.05$

4.8.1 Prevalence of Hypertension

The overall prevalence of hypertension was 57.5% among all inmates followed by pre-hypertension (28.8%). Normal subjects constituted 13.8% of the total study population. Prevalence was highest among female inmates (90%) followed by males housed at the Manhyia local prison (63.2%) and lastly the Kumasi central prison (54.2%). The prevalence of prehypertension was 30.5% for the Kumasi central prison, 10% for the Kumasi female prison and 26.3% for the Manhyia local prison.

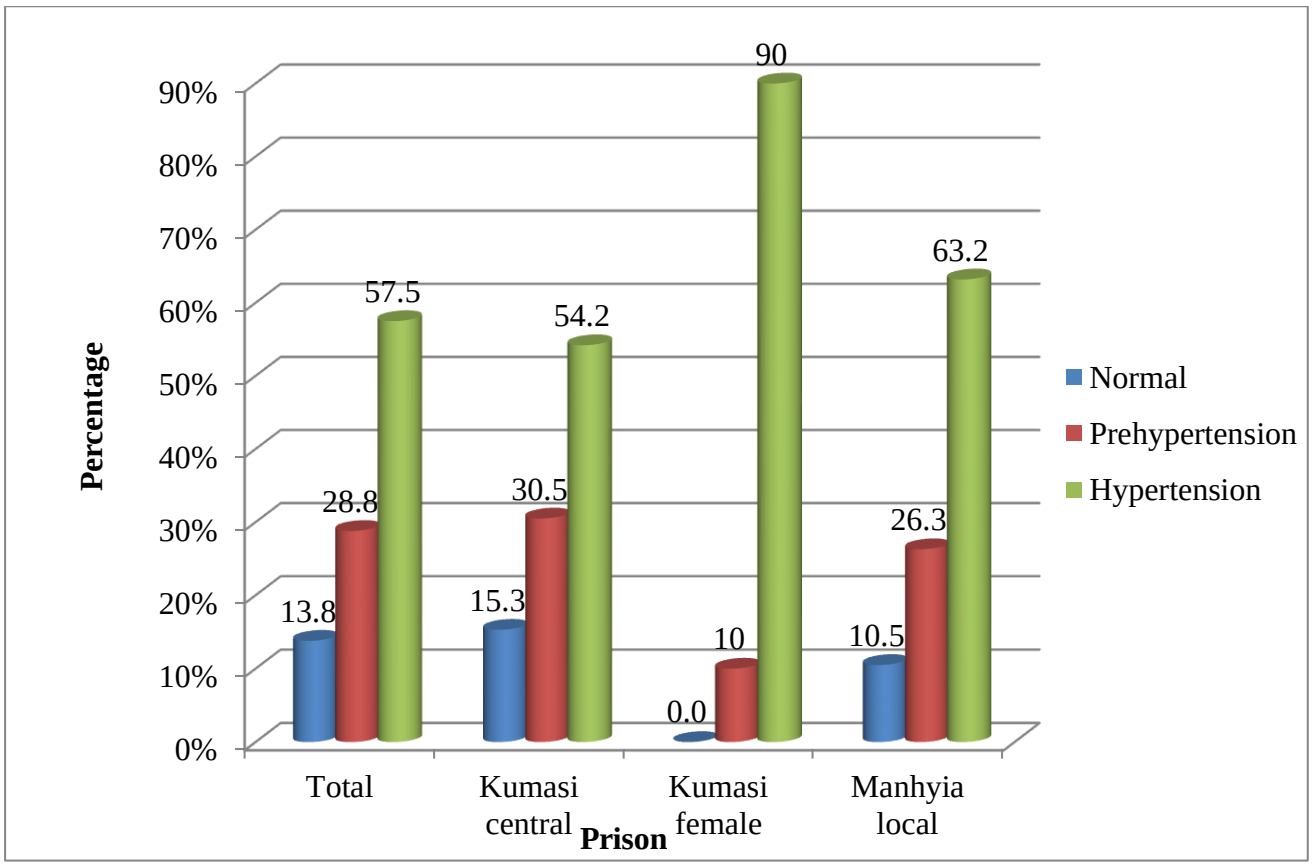

Figure 4.1 Prevalence of hypertension and pre-hypertension among inmates

4.8.2 Prevalence of Diabetes and Pre-diabetes

The overall prevalence of diabetes was 1.2%. Those who were pre-diabetic constituted 3.15%. About seven percent (6.9%) of all participants were hypoglycaemic and 88.8% had normal blood glucose. Diabetes was prevalent only at the Kumasi central prison (1.5%). The Kumasi female and the Manhyia local prisons had no cases of diabetes. Thirty percent (30%) of inmates from the Kumasi female prison were however pre-diabetic. Prevalence of pre-diabetes was 0.8% and 5.3% for Kumasi central prison and Manhyia local prisons respectively. The Kumasi central and Manhyia local prisons had 6.9% and 10.5% of their respective participants to be hypoglycaemic. Normoglycaemic subjects constituted 90.8%, 70% and 84.2% of participants from the Kumasi central, Kumasi female and Manhyia local prisons respectively.

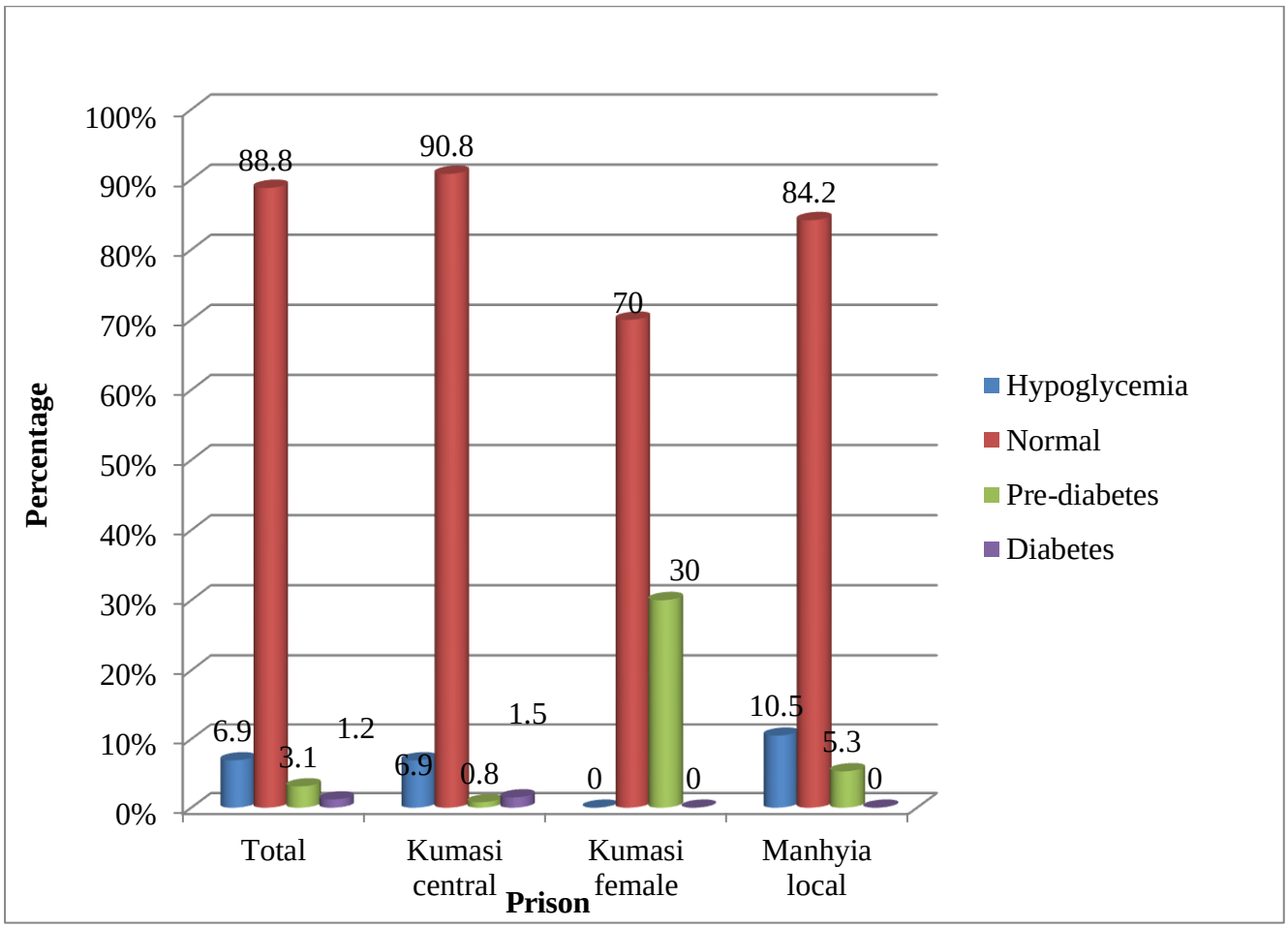

Figure 4.2 Fasting blood glucose characteristics of study participants

4.8.3 Prevalence of overweight and obesity

The overall prevalence of overweight and obesity by BMI for all prisoners was 16.3% and 6.3% respectively. Prevalence of central obesity was 4.7% among male inmates and 40% among females. The Kumasi central prison had an overweight and obesity prevalence of 16% and 5.3% respectively by BMI. The Kumasi female prison had 30% of its study participants to be overweight or obese. The Manhyia local prison had an overweight prevalence of 10.5% and no obese subjects. Prevalence of central obesity was 40% among female inmates, 4.6% for the Kumasi central prison and 5.3% for the Manhyia local prison.

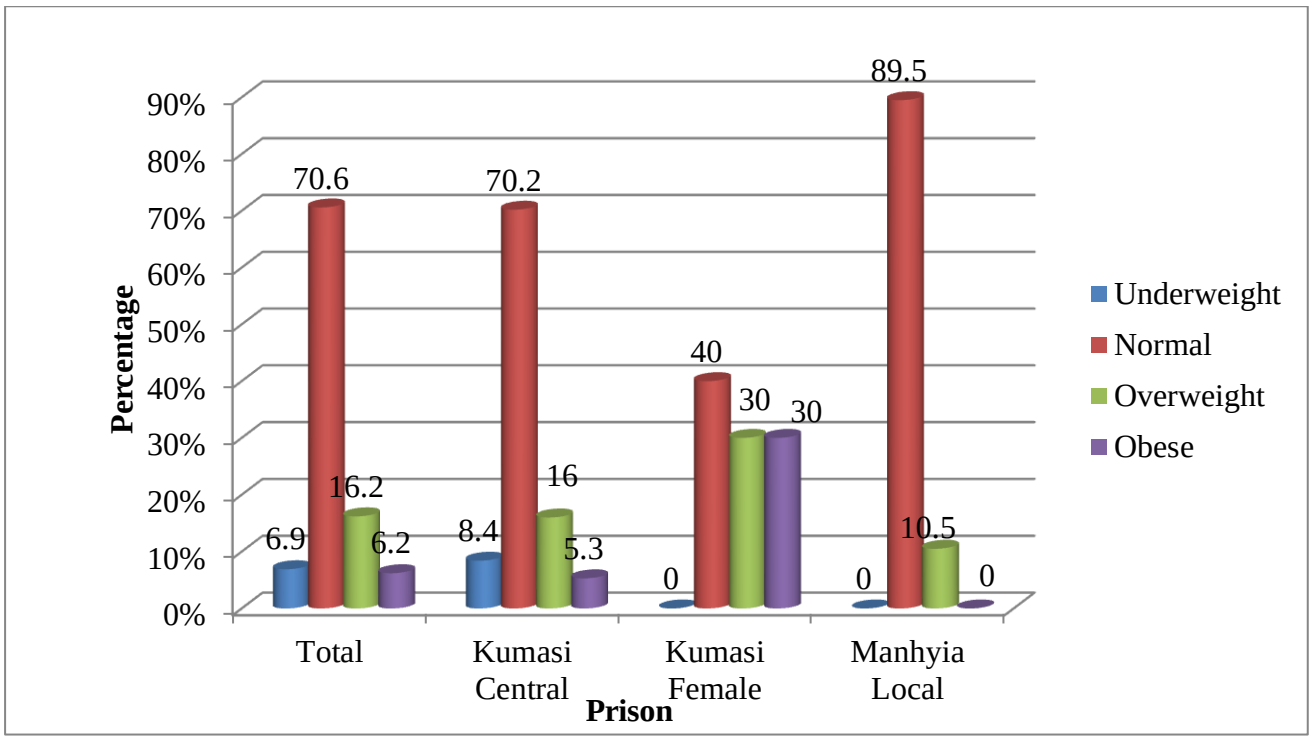

Figure 4.3 Prevalence of obesity by BMI among inmates

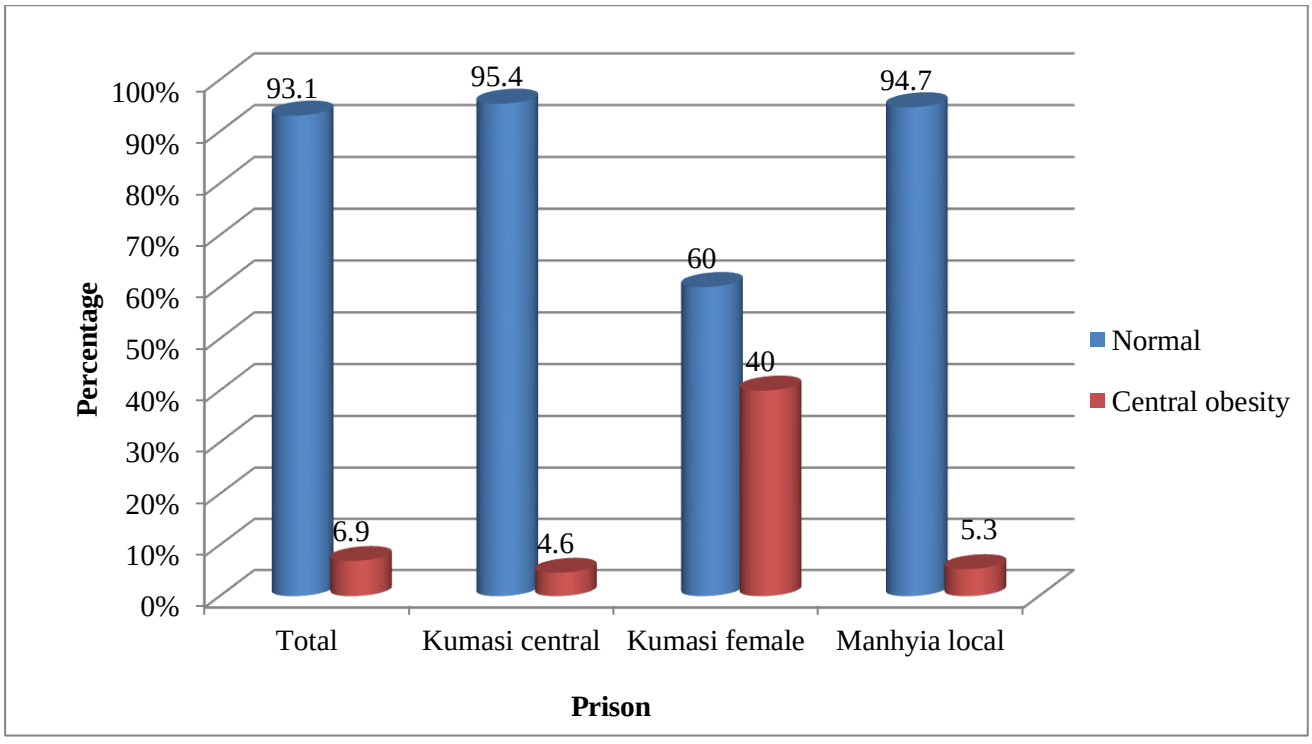

Figure 4.4 Prevalence of central obesity among study inmates

4.8.4 Prevalence of Dyslipidaemia

Data on lipid profile was missing for one person. The overall prevalence of reduced serum HDL was 16.9% for all study participants. Prevalence by prison was 15.4% for the Kumasi central, 10% for the Kumasi female and 31.6% for the Manhyia local prison.

Prevalence of elevated serum triglycerides was 16.3% for the entire study sample. Prevalence was 19.2% and 5.3% for the Kumasi central and Manhyia local respectively. The Kumasi female prison had no incidence of hypertriglyceridaemia. Those with high serum total cholesterol constituted 36.3% of the total inmate population. Prevalence of hypercholestrolaemia was 38.5% at the Kumasi central, 50% at the Kumasi female and 15.8% at the Manhyia local prison. Those with elevated serum LDL constituted 9.4% of the entire study participants. Prevalence was 9.2%, 20% and 5.3% for the Kumasi central, Kumasi female and Manhyia local prison.

In total, those with dyslipidaemia constituted 57.5% of the study population. Prevalence was 59.2%, 60% and 47.4% at the Kumasi central, Kumasi female and Manhyia local prisons respectively.

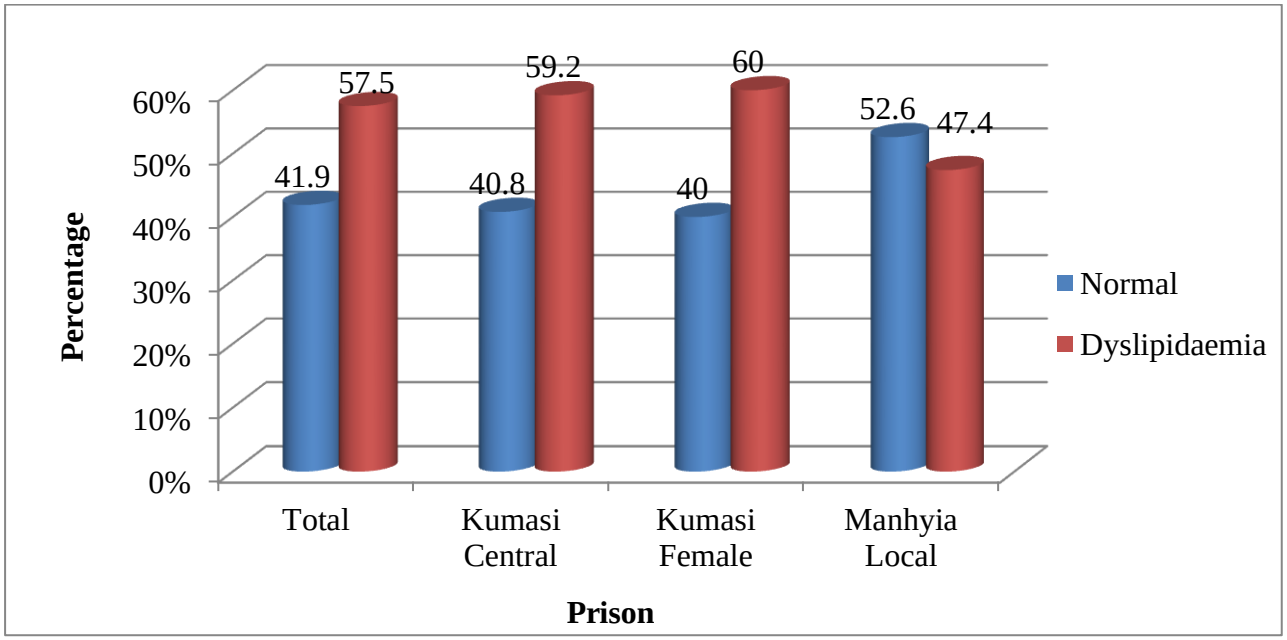

Figure 4.5 Prevalence of dyslipidaemia among study participants

4.8.5 Prevalence of Metabolic Syndrome

The total number of inmates who had metabolic syndrome constituted 8.1% of the study population. Prevalence was 6.1% for the Kumasi central prison, 40% for the Kumasi Female prison and 5.3% for the Manhyia local prison.

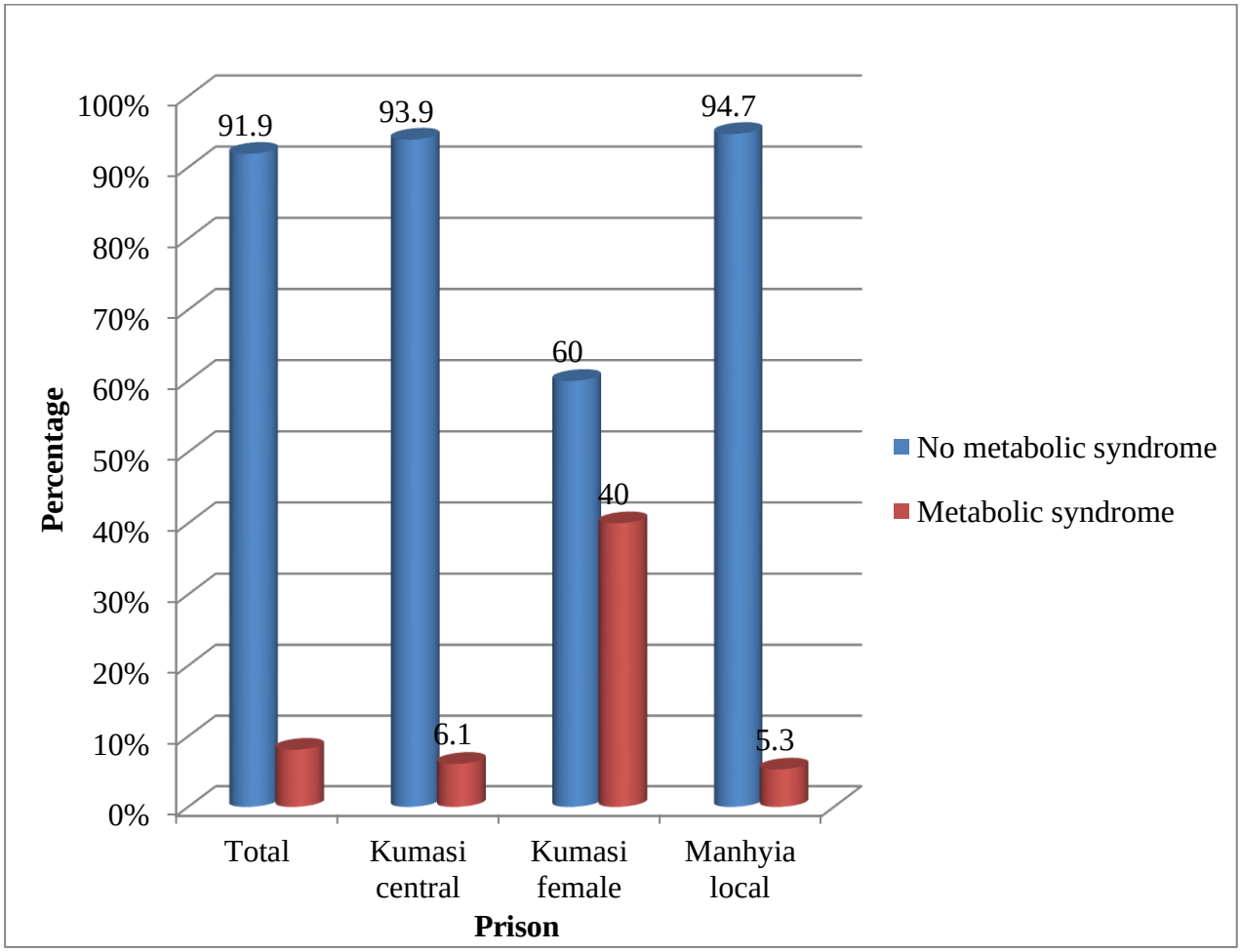

Figure 4.6 Prevalence of metabolic syndrome among inmates.

4.8.6 Overall Prevalence of metabolic syndrome and its parameters among study participants.

In total, 8.1% of inmates included in the study had no metabolic syndrome parameter. Approximately 62% (61.9%) had one parameter, 21.9% had two parameters and 8.1% had three or more parameters.

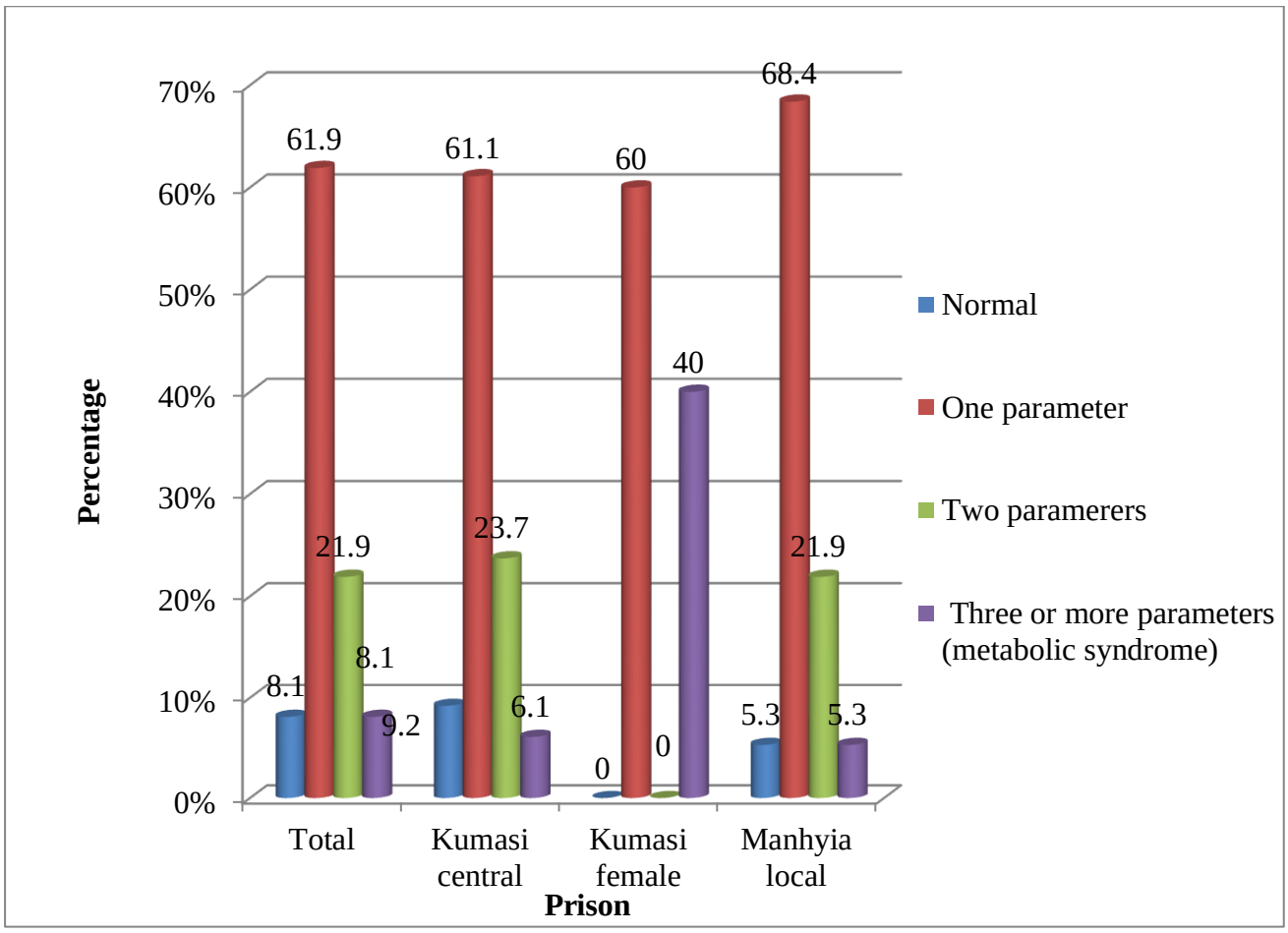

Figure 4.7 Overall Prevalence of metabolic syndrome and its parameters among study participants.

4.8.7 Prevalence of metabolic syndrome by Past lifestyle factors.

Table 4.8 displays the prevalence of metabolic syndrome by past lifestyle factors of inmates. The total percentage of inmates who had metabolic syndrome and drank alcohol in the past constituted 3.8% of inmates while 4.4% of those who did not drink in the past had metabolic syndrome. Of those who smoke in the past, 1.9% had metabolic syndrome while 6.2% of those who did not smoke had metabolic syndrome.

Inmates who were very active and those who were moderately active in the past had a metabolic syndrome prevalence of 2.5% each. Those who were active had a prevalence of

6.9% while those who were sedentary had no prevalence of metabolic syndrome. Association between all past life factors and metabolic syndrome was statistically insignificant.

Table 4.8 Prevalence of metabolic syndrome by past lifestyle factors

Past lifestyle factors	Total n(%)	No metabolic syndrome n(%)	Metabolic Syndrome present n(%)	P-value
Past alcohol intake				
Yes	78(48.8)	72(45.0)	6(3.8)	1.0
No	82(51.2)	75(49.9)	7(4.4)	
Past smoking				
Yes	69(43.1)	66(41.2)	3(1.9)	0.153
No	91(56.9)	81(50.6)	10(6.2)	
Past activity levels				
Very active	26(16.2)	22(13.8)	4(2.5)	
Moderately active	40(25)	36(22.5)	4(2.5)	0.250
Active	72(45)	67(41.9)	5(6.9)	
Sedentary	22(13.8)	22(13.8)	0(0.0)	

Data is presented categorically with percentages in parenthesis. Differences observed among all groups are statistically insignificant at 95% confidence interval.

4.9 Differences in nutrient intakes among inmates with metabolic syndrome and those without metabolic syndrome.

Table 4.9 shows the mean intakes of nutrients among inmates with metabolic syndrome and those without metabolic syndrome. Those with metabolic syndrome recorded higher intakes for all nutrients. The mean energy intake for those without metabolic syndrome was 1258.2±585.8kcal and 1385.1±890.9kcal for those with metabolic syndrome.

Average potassium intake was 1418.9±826mg and 1686.2±913.8mg for those without metabolic syndrome and those with metabolic syndrome respectively. Mean sodium intake was 2396.5±1220.5mg and 2441.4±1183.8mg for those without and those with metabolic syndrome respectively.

Those without metabolic syndrome had a mean vitamin E intake of 3.2±2.8mg and those with metabolic syndrome had a mean intake of 4.6 ± 4.0mg. Average vitamin B_6 intake was 1.2±0.7mg and 1.3±0.7mg for those with no metabolic syndrome and those with metabolic

syndrome respectively. Mean folate intake for those without metabolic syndrome was 199.7±221.3µg and 296.2±337.4µg for those with metabolic syndrome. Average vitamin C intake was 52.6±40.2mg and 59.4±4.3mg for those without and those with metabolic syndrome respectively. Average vitamin B_{12} intake was 0.966±3.1µg and 1.8±4.4µg for inmates without metabolic syndrome and those with metabolic syndrome accordingly. These differences were however not statistically significant as their p-values were greater than 0.05.

***Tabl*e 4.9 Differences between nutrient intakes among inmates with metabolic syndrome and those without metabolic syndrome**.

Nutrient Intakes	**Mean intakes**		**p-value**
	No metabolic syndrome n=147	Metabolic syndrome n=13	
Energy (kcal/d)	1258.2±585.8	1385.1±890.9	0.623
Potassium (mg/d)	1418.9±826.0	1686.2±913.8	0.326
Sodium (mg/d)	2396.5±12205	2441.4±1183.8	0.898
Vitamin E (mg/d)	3.2±2.8	4.6±4.0	0.234
Vitamin B_6 (mg/d)	1.2±0.7	1.3±0.7	0.457
Folate (µg/d)	199.7±221.3	296.2±337.4	0.330
Vitamin C (mg/d)	52.6±40.2	59.4±43	0.591
Vitamin B_{12} (mg/d)	0.966±3.1	1.8±4.4	0.518
Fibre (g/d)	20.1±10.4	21.3±10.3	0.677
Protein (%AMDR/d)	8.6±2.7	10.0±2.8	0.110
Fat (%AMDR/d)	19.7±7.8	21.1±10.0	0.645
Carbohydrate (%AMDR/d)	71.7±8.4	69.0±11.3	0.406

Categorical data on mean nutrient intakes among inmates with metabolic syndrome and those without metabolic syndrome. Differences observed between means for all nutrients are statistically insignificant.

4.9.1 Association between Nutrient Intakes and Metabolic Syndrome Parameters.

Table 4.10 summarizes the association between mean nutrient intakes and means of metabolic syndrome parameters. A positive correlation was found between mean energy intake and the means of all metabolic parameters except for HDL with which it exhibited a negative correlation (r = -0.056). All associations were however not significant as their p-values were greater than 0.05. Fat intake exhibited an association similar to energy intake been positive for all parameters except for HDL (-0.035) at p-values that were not statistically significant (p>0.05).

Vitamin B_6 negatively correlated with waist circumference, BMI and HDL and positively with the other parameters at p-values that were statistically not significant. A negative association between vitamin B_{12} and waist circumference (r = -0.015), BMI (r = -0.023) and triglycerides (r = -0.001) were found but these associations were statistically insignificant. A significant positive relationship was however found between vitamin B_{12} and systolic blood pressure (r = 0.226, p = 0.004). Vitamin B_{12} had a positive insignificant relationship with diastolic blood pressure, FBS and HDL. A significant positive relationship was found between folate and BMI (r = 0.184, p 0.020) and systolic blood pressure (r = 0.186, p = 0.018). Associations with other parameters were positive but insignificant except for HDL with which it exhibited a non-significant negative relationship.

Association between vitamin E and waist circumference as well as triglycerides were negative but insignificant. An insignificant positive relationship was found between vitamin E and BMI, systolic blood pressure, diastolic blood pressure, and FBS. Vitamin C had a negative correlation with BMI, waist circumference, HDL and triglycerides but these associations were insignificant. Vitamin C was insignificantly positively associated with systolic pressure, diastolic pressure and FBS. Potassium exhibited a positive significant correlation with systolic blood pressure (r = 0.172, p= 0.030), diastolic blood pressure (r = 0.164, p =0.039) and FBS (r = 0.191, p = 0.015). It exhibited an insignificant negative

relationship with HDL and positive relationship with BMI, waist circumference and triglycerides. Sodium exhibited a weak positive relationship waist circumference, BMI, FBS, systolic blood pressure and diastolic blood pressure but its positive relationship with triglycerides was statistically significant ($r = 0.212$, $p=0.007$). A negative correlation was found between HDL and sodium ($r = -0.018$, $p =0.822$).

Percentage protein intake was positively associated with BMI ($r=0.209$, $p= 0.008$), systolic blood pressure($r=0.171$, $p= 0.031$) and FBS ($r=0.161$, $p=0.042$).

All parameters that exhibited significant associations were weakly correlated.

Table 4.10 Association between Mean Nutrient Intakes and Means of Metabolic Syndrome Parameters

Nutrient Intakes	Waist circumference r(p-value)	BMI r(p-value)	Systolic blood pressure r (p-value)	Diastolic blood pressure r (p-value)	FBS r(p-value)	Triglycerides r (p-value)	HDL r (p-value)
Energy	0.081(0.306)	0.066 (0.405)	0.122 (0.124)	0.118 (0.137)	0.089(0.265)	0.146(0.067)	-0.056 (0.482)
Fat	0.043(0.589)	0.028(0.728)	0.089(0.262)	0.097(0.224)	0.083(0.296)	0.027(0.738)	-0.035(0.665)
Vitamin B_6	-0.003(0.974)	-0.018(0.821)	0.123(0.121)	0.104(0.189)	0.060(0.447)	0.064(0.425)	-0.150 (0.058)
Vitamin B_{12}	-0.015(0.850)	-0.023 (0.773)	0.226 (0.004)*	0.145 (0.068)	0.131(0.099)	-0.001(0.993)	0.023(0.775)
Folate	0.055(0.492)	0.184(0.020)*	0.186 (0.018)*	0.151 (0.057)	0.131(0.098)	0.023(0.771)	-0.012 (0.876)
Vitamin E	-0.011(0.892)	0.049 (0.537)	0.140 (0.078)	0.092 (0.250)	0.078(0.325)	-0.065(0.417)	-0.101(0.206)
Vitamin C	-0.014(0.863)	-0.012 (0.884)	0.084 (0.293)	0.119 (0.134)	0.097(0.223)	-0.043(0.593)	-0.141(0.077)
Potassium	0.011(0.892)	0.048 (0.546)	0.172 (0.030)*	0.164 (0.039)*	0.191(0.015)*	0.113(0.155)	-0.066 (0.411)
Sodium	0.053(0.506)	0.044 (0.578)	0.067 (0.403)	0.084 (0.291)	0.045(0.570)	0.212(0.007)*	-0.018 (0.822)
% Protein	0.139(0.080)	0.209(0.008)*	0.171(0.031)*	0.091(0.254)	0.161(0.042)*	-0.029(0.718)	-0.049(0.543)
%Fat	0.005(0.950)	-0.007(0.929)	0.028(0.729)	0.051(0.525)	0.099(0.215)	-0.076(0.344)	0.028(0.727)
%Carbohydrate	-0.047(0.555)	-0.057(0.477)	-0.085(0.287)	-0.081(0.301)	-0.141(0.075)	0.081(0.310)	-0.015(0.848)
Fibre	0.103(0.194)	0.072(0.366)	0.073(0.359)	0.132(0.097)	0.076(0.338)	0.185(0.020)	0.005(0.946)

Correlational analysis between nutrient intakes and metabolic parameters. * depicts correlations that are significant at $p<0.05$.

4.9.2 Partial correlation between mean nutrient intakes and metabolic syndrome.

Sodium had a positive association with triglyceride level (r=0.201, p=0.008). Vitamin B12 had a positive correlation with systolic blood pressure (r=0.192, p=0.016). Folate had a positive correlation with systolic blood pressure (r=0.165, p=0.038). Protein had a positive association with BMI (r=0.187, p=0.019), FBS (r=0.162, p=0.043) and systolic blood pressure (r=0.220, p=0.006). Potassium had a positive relationship with systolic blood pressure (r=0.161, p=0.044). All significant associations observed were however weak after adjusting for age and gender.

Table 4.11 displays partial correlation between mean nutrients intakes and metabolic syndrome.

Table 4.11 Partial correlation between nutrient intake and metabolic syndrome parameters.

Nutrient Intakes	Waist circumference r(p-value)	BMI r(p-value)	Systolic blood pressure r (p-value)	Diastolic blood pressure r (p-value)	FBS r(p-value)	Triglycerides r (p-value)	HDL r (p-value)
Energy	0.055(0.490)	0.049(.0542)	0.087(0.276)	0.093(0.249)	0.057(0.475)	0.135(.0.092)	-0.067(0.404)
Vitamin B_6	-0.012(0.885)	-0.024(0.762)	0.123(0.124)	0.104(0.195)	0.052(0.518)	0.059(0.462)	-0.154(0.054)
Vitamin B_{12}	-0.043(0.590)	-0.035(0.667)	0.192(0.016)*	0.117(0.144)	0.110(0.170)	-0.019(0.817)	0.011(0.891)
Folate	0.034(0.675)	0.127(0.112)	0.165(0.038)*	0.116(0.148)	0.082(0.310)	0.041(0.609)	-0.014(0.861)
Vitamin E	-0.018(0.825)	0.002(0.984)	0.148(0.064)	0.080(0.318)	0.048(0.550)	-0.046(0.571)	-.0098(0.221)
Vitamin C	-0.049(0.543)	-0.054(0.504)	0.033(0.682)	0.079(0.326)	0.051(0.529)	-0.051(0.523)	-0.153(0.055)
Potassium	0.007(0.929)	0.006(0.945)	0.161(0.044)*	0.145(0.069)	0.161(0.044)*	0.124(0.123)	-0.068(0.397)
Sodium	0.058(0.470)	0.060(0.453)	0.090(0.260)	0.107(0.183)	0.056(0.485)	0.210(0.008)*	-0.017(0.832)
% Protein	0.159(0.046)	0.187(0.019)*	0.220(0.006)*	0.107(0.184)	0.162(0.043)*	0.001(0.986)	-0.037(0.643)
%Fat	-0.016(0.839)	-0.049(0.545)	-0.002(0.981)	0.022(0.780)	0.062(0.437)	-0.074(0.360)	0.024(0.763)
%Carbohydrate	-0.032(0.686)	-0.010(0.899)	-0.072(0.373)	-0.059(0.464)	-0.107(0.182)	0.070(0.383)	-0.016(0.846)
Fibre	0.093(0.246)	0.059(0.462)	0.063(0.431)	0.126(0.117)	0.059(0.462)	0.184(0.021)*	0.002(0.977)

Partial correlation between nutrient intakes and metabolic parameters. * depicts correlations that are significant at $p<0.05$.

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Background and Incarceration Characteristics of Participants

Male inmates (93.8%) dominated the study population and a majority of participants belonged to the lowest age of inclusion (40.6%). This implies that the Ghanaian penal system is dominated by young males. Globally, all prisons systems are male dominated and most researches have reported far less proportion of female inmates in comparison to males. A study conducted by Fawad *et al*., (2010) involved only twenty female prisoners as opposed to one hundred and forty six male prisoners. Also Kamar *et al*., (2013) had only thirteen out of a total of three hundred inmates involved in a study to be females. Younger people all around the world also continue to battle with various crimes and older inmates are a recently increasing prison population (Harris *et al*., 2007; Loeb *et al*., 2014; WHO, 2014) which is also consistent with findings from the study.

Educational characteristics of inmates discovered in this study shows that most prisoners (53.1%) in Ghana have completed only basic education and this is similar to data from the 2013 annual report of the Ghana Prisons Service which indicates that most inmates (47%) completed junior high school which represents basic education. Socio- economic data from this study confirms the findings of other studies that have also reported on the low socio-economic and disadvantaged backgrounds of prisoners. Prisoners all over the world are drawn mostly from socio-economic disadvantaged populations with weak educational backgrounds (Bautista-Arredondo *et al*., 2015; Herrington, 2009).

The Christian faith practice by majority of inmates (76.3%) included in the study further confirms the religious characteristics of inmates in the 2013 annual report of the Ghana Prisons Service. Findings of this study also show that most prisoners in Ghana are married. Kumar *et al*, (2013) in consistence with this finding also reported that most inmates were married.

5.2 Daily Nutrient Provision within the Prisons

Household record was used to estimate nutrients from ingredients. Caloric provision was in excess for all prisons and exceptionally higher for female inmates. Macronutrients provided were outside suggested ranges of the AMDR for all prisons except for fat which was within the suggested range of AMDR only for the Kumasi central (26.3%) and Manhyia local (27.7%) prisons but in excess for the Kumasi female prison (35.9%). Excessive fat and caloric provision to female inmates is a contributing factor to high prevalence of overweight and obesity observed among female prisoners compared to males (Clarke and Waring, 2012; Gates and Bradford, 2015; Vera-Remartínez *et al.,* 2014; Wolff *et al.,* 2012). Protein was lower than recommendations for the Kumasi central (6.8%) and Manhyia local (8.1%) prisons but adequate for inmates at the Kumasi female prison (28.2%). Carbohydrate was provided in excess of the AMDR for male prisoners and lower for female inmates. Protein foods especially those from animal sources are a rich source of vitamin B_{12} and low provision put inmates at risk of deficiency diseases such as anaemia which is a leading cause of death among Ghanaian inmates (Ghana Prisons Service, 2012; Rolfes *et al.,* 2014). These findings contradict data from other studies which found macronutrients provided by prisons foods to be within suggested ranges of the AMDR (Collins and Thompson, 2012; Cook *et al*., 2015). Specifically, Cook *et al*., (2015) found that fat provided 34% of total calories, carbohydrate provided 55% and protein 12%. However higher caloric provision to female inmates compared to males is consistent with existing data (Collins and Thompson, 2012; Cook *et al*., 2015).

Fibre provided was in excess of the RDA for females (42.4g/d) but inadequate for male prisoners (28.2g/d) especially for those housed at the Manhyia local prison. Adequate fibre intake guards against cardiovascular diseases but among female inmates, high fibre provision was not seen to be protective against metabolic syndrome or its parameters as it was accompanied with high quantities of fat (De Souza *et al.,* 2015). Though the fibre provision

did not meet recommendations for males, some studies have reported far less provision compared to what was found in this study. This may be due to the fact that menus obtained by the other studies were highly processed and therefore fibre deficient. The Collins and Thompson (2012) study for instance reported average fibre provision of 16g/day in their study.

The sole dependence on fresh unprocessed foods in Ghanaian prisons accounts for the relatively high fibre provision found in this study. The feeding rate for a prisoner per day is 1.80 cedis and processed foods are expensive in Ghana and are therefore not a resort in feeding inmates but female inmates receive a lot of donations accounting for their high nutrient and caloric provision.

All micronutrients provided were in excess for females but inadequate for male prisoners with the exception of iron which was in excess for all prisons, potassium which was inadequate for all inmates and sodium which was adequate for the Kumasi central prison and in excess for the Manhyia local prison. Inadequate vitamin and mineral provision within prisons has caused outbreak of deficiency diseases such as beriberi, scurvy and night blindness among prisoners (Gould *et al*., 2013; Lanska, 2015). Some of the symptoms of these deficiency diseases lead to impairment in cardiovascular health and subsequent cardiovascular disease (Song *et al*., 2014). Additionally, inadequate micronutrients in the diet especially potassium, vitamin E and can cause an increase in blood pressure (Gupta *et al.,* 2014; Pounis *et al.*, 2013).

Sodium provided by the Kumasi female prison (3939.4mg/day) and Manhyia local prison (3415.6mg/day) was above the tolerable upper intake level. High sodium provision predisposes inmates to hypertension and cardiovascular diseases (Whelton *et al*., 2012). This may explain the high prevalence of hypertension observed especially among inmates at the Kumasi female and Manhyia local prisons.

Even though micronutrients were in excess for females, these were accompanied with high calories which are not readily consumed and this supports data on the low nutrient value of prison foods (Eves and Gesch, 2003).

Reformation is the ultimate goal of incarceration and adequate vitamins and minerals help reduce aggression and criminal behaviour. Supplementation with magnesium, copper, zinc, vitamin B_6 and vitamin C among other vitamins and minerals reduce aggressive behaviour among inmates (Young, 2007). Inadequate nutrient provision therefore poses a double risk of high rates of cardiovascular diseases and reoffending.

5.3 Actual Nutrient intakes of inmates

Actual nutrient intakes were estimated from a 24 hour recall. Caloric intake was low for all prisons. The mean intake of fat (19.8%) was adequate in all prisons but carbohydrate intake was in excess of the AMDR for all prisoners. Protein intake showed similar patterns with protein provision being inadequate for male inmates but adequate for females. Fibre, potassium, vitamin E, vitamin C, vitamin B_{12} and zinc intakes were inadequate for all inmates but sodium intake was in excess among all prisoners. Vitamin B_6 intake was adequate for the Manhyia local prison but inadequate for the Kumasi central and Kumasi female prisons. Folate intake was inadequate for male prisoners but adequate for females. In contrast, iron intake was adequate for male inmates but inadequate for females and this predispose female prisoners to iron deficiency anaemia and poor pregnancy outcomes during and post imprisonment (Walker *et al*., 2014).

Excessive sodium intake is a risk factor for hypertension especially when coupled with low intakes of potassium and antioxidant vitamins (Aburto *et al*., 2013; Niki, 2016; Pimenta *et al*., 2009; Singh *et al*., 2015). Vitamin E and C are potent antioxidant micronutrients that reduce oxidative stress and protects against cardiovascular diseases (Pham-Huy *et al*., 2008). Low fibre intake is a predisposition to hypertension and dyslipidaemia (Sharma, 2016).

Vast differences existed between nutrient provision and supply and most inmates consumed less of nutrients and calories compared to what was provided. This finding may be as a result of underestimation of food portions by inmates or their inability to remember all foods consumed. It may also be a deliberate attempt of inmates to underestimate food portions because mass attempt to break jail has occurred in some Ghanaian prisons and inmates said it was a way to protest against poor diets provided to them. Prisons in Ghana operate on a static menu and continual repetition of foods can also contribute to low intakes by inmates (Carpenter, 2006). Eves and Gesch (2003) also reported that the nutritional intakes of inmates are significantly less than what was provided by the kitchen. This goes a step further to lessen already inadequate nutrients provided especially for male inmates.

Majority of inmates (73.1%) included in this study consumed foods outside of the prison menu. The Kumasi central prison and Manhyia local prisons provide two meals per day. Lunch and supper are provided together for male inmates but inmates at the Kumasi female prison are provided three square meals separately. But in addition to foods consumed outside a large number of inmates (69.4%) most of the times ate only twice daily. It can therefore be said that prison food consumption by most inmates was low. Prison foods however continue to be the sole source of nutrients and calories for majority of inmates as those who ate outside the prison (52.5%) mostly did so occasionally. Foods consumed outside the prison menu were high in fats and sodium. This is because foods brought in by family members should be foods that can keep long because individualised cooking is not allowed within the prisons. These preserved foods are generally high in fats and salt and excludes vegetables and fruits further worsening the plight of prison foods. This finding is similar with data from a study conducted in the United States of America which also found that foods consumed outside the prison menu was high in sodium and saturated fats (Cook *et al*., 2015).

5.4 Prevalence of metabolic syndrome parameters

Prevalence of hypertension (57.5%) and pre-hypertension (28.8%) was very high among study participants. Those who had normal blood pressure level only constituted 13.8% of study participants. Mean potassium provided by all prisons was below the RDA while sodium was in excess for most prisoners which may explain the high occurrence of hypertension. Hypertension is a leading risk factor for cardiovascular diseases and the third cause of all global deaths (Santulli, 2013). The 2012 report on inmate mortality by the Ghana prisons service shows that cardiovascular events (18.7%) are the leading cause of death and hypertension precedes most cardiovascular episodes. Other studies have also found high prevalence of hypertension among prisoners. Fawad *et al*., (2012) reported that systolic blood pressure was greater 140mm Hg for 34.33% of inmates while diastolic blood pressure was greater than 90mm Hg for 61.44%. Gates and Bradford (2015) reported a prevalence of 21% among inmates. Continual treatment and control of high blood pressure is essential in reducing future cardiovascular risk (WHO, 2016) but only 11.9% of all those whose blood pressure satisfied the diagnostic criteria for hypertension had been diagnosed and out of this percentage 10.6% were on medication but none of them was on special diet. Dietary modification is essential in controlling hypertension. High intake of sodium is antagonistic to hypertensive drugs but increased fruits and vegetables help lower blood pressure (Pimenta *et al*., 2009) . Vera-Remartínez *et al*., (2014) also found that some inmates fulfilled diagnostic criteria for certain diseases but were not diagnosed.

Prevalence of dyslipidaemia was very high among study participants. Dyslipidaemia may be as a result of disordered eating patterns observed among inmates. Lack of fruits and vegetables in the diet of most inmates also contribute to dyslipidaemia. High dependence on fat to meet caloric needs especially among female inmates may explain the high occurrence of dyslipidaemia among them (Sharma, 2016). Vera-Remartínez *et al*., (2014) reported a prevalence of 34.8% among prisoners in Spain and this is lower than what was found in this

study. Fawad *et al.*, (2012) reported a prevalence of 39.75% among inmates in Pakistan which is also lower than prevalence found in this study. Elevated serum LDL and reduced HDL is an atherogenic lipid profile and predisposes inmates significantly to cardiovascular diseases (Acharjee *et al.*, 2013). Oily fish and fish oils help increase serum HDL levels but these are completely missing in the prisons' menu.

Inmates who were overweight or obese by BMI constituted 22.6%. The mean BMI of study participants was 22.8. Prevalence of central obesity was however low especially among male inmates. Female prisoners had higher obesity prevalence and this can be explained by higher calories provided to them (Cook *et al.*, 2015). Most studies conducted in developed countries have found a higher mean BMI than what was found in this study. Leigey and Johnston (2015) recorded a mean BMI of 28.8 among prisoners in the United States. Togas *et al.*, (2014) found a mean BMI of 25.68 among Greece prisoners.

Though mean BMI found in this study was low, Ghanaian prison may start experiencing higher rates of overweight and obesity if inmates start consuming food quantities that are reflective of what is provided. Project effiase has been launched by the Ghana Prisons Service to help improve inmate living conditions as well as provide better nutrition to inmates. Improvement in the quality and variability of foods may lead to higher intakes than observed in this study. If calories provided remains unchanged, Ghanaian prisons will begin to experience rates of chronic diseases comparable to what is been faced by prisons in the developed world or even worst.

Prevalence of diabetes was 1.2%. The percentage who were pre-diabetic (3.1%) was also small. High fibre provision and low caloric intakes observed among study participants may play a protective role against diabetes. Silverman-Retana *et al.*, (2015) comparatively reported a prevalence of 1.58% among inmates included in their study. Other studies have however reported a relatively higher prevalence than what was found in this study. Bai *et al.*, (2015) for instance reported a prevalence of 5.1%. Some inmates were hypoglycaemic

(6.9%). Hypoglycaemia is associated with aggressive behaviour and can interfere with the reformation process (Benton, 2007). Hypoglycaemia can also suggest improperly managed diabetes (Desouza *et al*., 2010).

The total number of inmates with metabolic syndrome was 8.1%. Prevalence was higher among female (40%) inmates compared to males (11.4%). Insulin resistance and central obesity are the driving forces to metabolic syndrome but prevalence of these conditions were low among inmates accounting for low metabolic syndrome prevalence (Samson and Garber, 2014). High prevalence of overweight and obesity put female inmates at a higher risk of metabolic syndrome. The overall prevalence of metabolic syndrome found among inmates is lower than the percentage of 18% that Akpalu *et al*., (2011) found among the free Ghanaian population. Silverman –Retana *et al.,* (2015) however reported a percentage of 2.91% among inmates included in their study and this is less than what was found in this study. Those who had two parameters of metabolic syndrome constituted 21.9% of the study population. An increase in metabolic syndrome can be realized in later years if interventions are not commenced in the Ghanaian penal system. Metabolic syndrome poses a double fold risk to the development of cardiovascular diseases and a five-fold risk to the development of diabetes mellitus (Alshehri, 2010).

The mean BMI, mean diastolic and systolic blood pressure, mean FBS and mean triglycerides were significantly different between male and female inmates with female inmates recording higher means for all these parameters with the exception of mean triglycerides. This is attributed to higher calories provided to female inmates compared to males (Clarke and Waring, 2012; Cook *et al.,* 2015; Vera-Remartínez *et al.,* 2014).These findings support data from several studies that have also found high prevalence of metabolic syndrome parameters among female inmates compared to males (Gates and Bradford, 2015; Vera-Remartínez *et al*., 2014; Wolff *et al*., 2012).

5.5 Association between Nutrient intakes and Metabolic Syndrome

Pearson correlation was used to determine relationship between nutrients intake and metabolic syndrome parameters. Independent t-test was used to determine differences in nutrient intake among inmates with metabolic syndrome and those without metabolic syndrome. Vitamin B_{12} (r=0.226, p=0.004) and folate (r=0.186, p=0.018) intakes significantly weakly correlated with systolic blood pressure and the relationship between potassium intake and diastolic (r=0.164, p=0.039) as well as systolic blood(r=0.172, p=0.030) pressure were significant but weak. This suggests that as intakes of these nutrients increase the risk of developing the conditions also increase. These findings are in contrast with existing studies that have documented the protective role of vitamin B_{12}, folate and potassium against metabolic risk factors (Appel *et al*., 1997; Adaikalakoteswari *et al*., 2014).

Chief sources of potassium from ingredients weighed in the prisons included groundnut, beans, salted fish, tomato puree and corn dough. Groundnut is also a good source of folate and is used in the preparation of groundnut soup which is accompanied with large quantities of oil. A large amount of palm oil accompanies the preparation of beans and salted fish comes along with it high quantities of sodium. Tomato puree is also a good source of potassium to inmates but it comes along with it high quantities of sodium. These high fat, high sodium sources of potassium and folate may contribute to why the protective role of potassium and folate were not seen in this study (Ralston *et al*., 2012). The mean potassium intake was low and may also explain its positive correlation with systolic and diastolic blood pressure (Aburto *et al*., 2013).

Animal source foods are the main contributors of vitamin B_{12} in the diet. They are however provided in very little quantities within the prisons. Majority of inmates resort to shito, fried herrings and sardine as a source of animal protein and vitamin B_{12}. Reliance on these high fat, high sodium sources of vitamin B_{12} and protein may explain their positive significant association with systolic blood pressure. Sodium (r=0.212, p=0.007) intake significantly

correlated with triglyceride level. High sodium intakes usually comes along with high calories and fat leading to this association (Baudrand *et al.* 2014). Other studies have however found opposing results (Graudal *et al*., 2011; Hoffmann and Cubeddu, 2009).

It was also observed from this study that individuals with no metabolic syndrome had lower intakes of energy and other nutrients compared to those with the syndrome but differences between their means were not significant. There is paucity of data to support protective role of non-excessive caloric intake and low intakes of fat in protecting against metabolic syndrome (Edwardson *et al.,* 2012; English and Uller, 2016).)

The assessment of three 24 hour recalls would have been more representative of inmate usual intakes and would have brought about significant differences than one 24 hour recall. Inmates might have also overestimated or underestimated their intakes which led to most correlations and comparisons been insignificant.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

This study assessed the prevalence of metabolic parameters (hypertension, dyslipidaemia, obesity and diabetes) and its dietary associated factors among older prisoners in the Ashanti Region of Ghana. It was hypothesized that prevalence of metabolic risk factors for cardiovascular diseases among older inmates exceeds 40%.

Protein, fibre, vitamin E, vitamin C, vitamin $B_{12,}$ folate and zinc provided were inadequate for male inmates. Female inmates had high quantities of most nutrients but these were accompanied with very high calories that also predisposed them to cardiovascular diseases.

Among the parameters assessed prevalence of hypertension (57.5%) was very high. Mean systolic and diastolic blood pressure was 141.1±23.2 and mean diastolic was 88.9±14. Prevalence of dyslipidaemia was also high, 57.5% of the inmates had dyslipidaemia. The overall prevalence of metabolic syndrome was 8.1%. Differences in nutrient intakes between inmates with metabolic syndrome and those without metabolic syndrome were not significant. In addition most nutrients did not correlate significantly with metabolic parameters. Potassium intake correlated significantly with systolic and diastolic blood pressure and FBG, vitamin B12, protein and folate had a positive association with systolic blood pressure. Sodium intake positively correlated with triglyceride levels.

6.2 Recommendations

The following recommendations are made based on findings of this study. The nutritional provision to inmates especially male inmates should be improved and salt used for meal preparation should be reduced. Fruits should be included in the prison's menu and quantities of vegetables, meat and fish should be increased to improve vitamin B12 and protein

provision. Philanthropic societies and groups that donate to female prisoners should also turn some of their resources to male inmates to help improve their nutritional status.

Also in the light of this finding the government is pleaded with to increase the feeding rate of 1.80 cedis per day for each prisoner as this is inadequate to provide optimal nutrition to inmates. Frequent health screening such as blood pressure check can be done routinely to detect cases of hypertension.

6.3 Limitation

The use of one 24-hour recall is a main limitation to this research work and thus information on nutritional intakes may not be reflective of usual intakes of inmates. Further researches should use the recommended three day 24-hour recall to assess inmate nutritional intakes. Also waste was not estimated from weighed ingredients and inmates may be entitled to lower quantities than reported in this study.

Further researches that would look at inmates' nutritional status and assess serum levels of nutrients are needed to confirm the extent of malnutrition and its impact on cardio metabolic health within the prisons.

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APPENDICES

APPENDIX A

QUESTIONNAIRE FOR INMATES

I am Nana Ama Frimpomaa Agyapong a student of Kwame Nkrumah University of Science and Technology; I am conducting a research on the topic "Metabolic syndrome parameters and their associated factors among older prisoners in the Ashanti Region of Ghana". The information obtained from this questionnaire is solely for research purposes and confidential. Please kindly provide answers to all the questions to the best of your ability.

Demographic Factors

1. Age 40-45 ☐ 46-50 ☐ 51-55 ☐ 56-60 ☐ above 60 ☐
2. Gender male ☐ female ☐
3. Level of education None ☐ JHS ☐ SHS ☐ Tertiary ☐
4. Marital status Single ☐ Married ☐ Divorced ☐ Widowed ☐
5. Religion Christian ☐ Muslim ☐ Traditionalist ☐ Other……
6. Previous occupation ……..
7. What is your length of sentence? ……
8. How long have you been in the prison?

   Less than one year ☐ 1-2 years ☐ 3-5 years ☐ More than five years ☐

Physical activity

9. Do you undertake any voluntary exercises?

   YES ☐ NO ☐

   If YES indicate the kind of exercise.

   Brisk walking ☐ Press ups ☐ Jogging ☐ Other……

10. How frequently do you engage in exercises?

    Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐

11. How much time do you normally spend on exercises?

Less than 30 minutes ☐ 30minutes ☐ 45minutes- 1hour ☐ more than 1hour ☐

12. Are you engaged in manual labour?

    YES ☐ NO ☐

13. If yes indicate the kind of manual labour you engage in.

    Digging ☐ Weeding ☐ Carrying of goods ☐ Other……

Dietary intake

14. How many times do you eat a day?

Once ☐ Twice ☐ Thrice ☐ Other……..

15. Do you eat other foods apart from the ones served in the prison?

YES ☐ NO ☐

16. How frequently do you eat foods other than that served in the prison?

Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐

17. List the foods you normally eat aside that served in the prison?

……

……

18. Do you take in alcohol?

YES ☐ NO ☐

19. How frequently do you take in fruits and vegetables?

Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐

20. 24 Hour food recall

Time	Foods eaten	Quantities

Health status

21. How frequently do you get sick?

Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐

22. How much time has elapsed since you last got sick? State the last time you got sick……..

23. Do you have any chronic diseases?

YES ☐ NO ☐

24. If YES state the chronic condition.……

25. Are you on any medication or special diet in relation to the chronic condition?

YES ☐ NO ☐

26. Are you able to comply with your drug intake and special dietary requirements?

YES ☐ NO ☐

Past lifestyle, dietary intakes and activity levels

27. Did you smoke in the past?

YES ☐ NO ☐

28. Did you drink alcohol in the past?

YES ☐ NO ☐

29. How would you rate your past level of physical activity?

Very active ☐ Moderately Active ☐ Active ☐ Sedentary ☐

30. List foods you normally ate in the past.

……

……

……

Anthropometric measurements	Biochemical Data
Weight ----	FBS
Height----	Serum HDL
Waist circumference----	Serum triglycerides
BMI----	Serum LDL
Blood pressure-----	Total cholesterol

APPENDIX B:

Participant Information Leaflet and Consent Form Used For the Research

This leaflet must be given to all prospective participants to enable them know enough about the research before deciding to or not to participate

Title of Research:

Metabolic syndrome parameters and their associated factors among older prisoners in the Ashanti region of Ghana.

Name(s) and affiliation(s) of researcher(s):

This study is conducted by Nana Ama Frimpomaa Agyapong, Student of Kwame Nkrumah University of Science and Technology, Kumasi and Dr. Reginald Annan of the Department of Biochemistry, KNUST, Kumasi.

Background (Please explain simply and briefly what the study is about):

Metabolic syndrome is a group of modifiable risk factors associated with increased risk of cardiovascular diseases and type 2 diabetes. Early assessment as well as early interventions has proved to be helpful in curbing this menace. This study intends to look at the prevalence of metabolic syndrome parameters as well as their associated factors among older prisoners in the Ashanti Region of Ghana.

Purpose(s) of research:

The purpose of this research to assess the prevalence of metabolic syndrome parameters and their associated factors among older prisoners in the Ashanti Region of Ghana.

Procedure of the research, what shall be required of each participant and approximate total number of participants that would be involved in the research:

Stratified random sampling will be used to select participants for the study from five prisons in Ashanti Region of Ghana. The blood pressure, weight circumference, weight and height of each participant will be checked. Venous blood of each participant will also be taken and analysed for lipid levels and fasting blood glucose levels. Information about past dietary intake and lifestyle such as smoking will be obtained by the use of questionnaire. Information on current food intakes and physical activity levels will also be obtained. In total 150 prisoners in Ashanti Region are expected to be recruited to form part of the study.

Risk(s):

Withdrawal of blood samples may cause pain.

Benefit(s): The goal of this research is to assess the prevalence of metabolic syndrome and its associated factors among older prisoners. The results of this research will provide information to policy makers on the need for interventions in correctional facilities to lower

cardiovascular risks. Prisoners who partake get to know their blood pressure, BMI and cardiovascular risk level for free.

Confidentiality:

All information collected in this study will be given code numbers. No names will be recorded. Data cannot be linked to you in any way. No names will be used in any publication or reports from this study. However, the ethical committee may have access to your records as part of our responsibility in conducting the research.

Voluntariness:

Taking part of this research is completely voluntary and out of free will. Prisoners are not obliged to participate.

Alternatives to participation:

Refusal of participation in this research will not affect the treatment of prisoners within the prisons.

Withdrawal from the research:

You may choose to withdraw from the research without having to explain yourself. You may also choose not to answer any question you find uncomfortable or private.

Consequence of Withdrawal:

There will be no consequences upon withdrawal from the study. Information obtained from you before you chose to withdraw from the research may have been used for analysis or publications and these cannot be removed anymore. We however promise to comply with your wishes as much as practicable.

Costs/Compensation:

You will receive a snack pack to compensate for your time and inconvenience to show our appreciation for your participation.

Contacts: If you have any concerns with regards to this study please do not hesitate to contact Miss Nana Ama Frimpomaa Agyapong on 0244942574 or the project supervisor Dr Reginald Annan on 0201237169.

Further, if you have any concern about the conduct of this study, your welfare or your rights as a research participant, you may contact:

The Office of the Chairman

Committee on Human Research and Publication Ethics Kumasi

Tel: 03220 63248 or 020 5453785

CONSENT FORM

Statement of person obtaining informed consent:

I have fully explained this research to _____ and have given sufficient information about the study, including that on procedures, risks and benefits, to enable the prospective participant make an informed decision to or not to participate.

DATE: _____ NAME: _____

Statement of person giving consent:

I have read the information on this study/research or have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary (not compulsory).

I know enough about the purpose, methods, risks and benefits of the research study to decide that I want to take part in it. I understand that I may freely stop being part of this study at any time without having to explain myself. I have received a copy of this information leaflet and consent form to keep for myself.

NAME:_____

DATE: _____ SIGNATURE/THUMB PRINT: _____

Statement of person witnessing consent (Process for Non-Literate Participants):

I _____ (Name of Witness) certify that information given to

_____(Name of Participant), in the local language, is a true reflection of what l have read from the study Participant Information Leaflet, attached.

WITNESS' SIGNATURE (maintain if participant is non-literate): _____

MOTHER'S SIGNATURE (maintain if participant is under 18 years): _____MOTHER'S NAME: _____

FATHER'S SIGNATURE (maintain if participant is under 18 years): _____

FATHER'S NAME: _____

APPENDIX C: Data Extraction Table (Summary of Studies on Cardiovascular risk factors among Prisoners from 2012 to 2016

CARDIOVASCULAR RISK FACTORS AMONG PRISONERS

Study source	Country	Prevalence of cardiovascular disease risk factors	Study design	Data collection procedures	Number of participants	Male	Female	Mean Age	Major findings	Quality assessment score
Fawad *et al*., (2010)	Pakistan	2% had RBS more than 180mg/dl. Addicted smokers were 21.7% and prevalence of physical inactivity was 71.7%, 60% had waist to hip ratio more than 0.9, 35% were overweight and 23.5 % were obese, 59% had no fruit intakes, 37.95% had cholesterol levels > 180ml/dl	Cross sectional study	Interview, anthropometric data, questionnaire, BMI, waist to hip ratio, lipid profile, ECG, RBS	166	146	20	62 years	Mean BMI was 26.52 ± 4.59 SD Mean systolic blood pressure 136.8 ± 22.91mm Hg, mean diastolic blood pressure 87.7 ± 11.93, mean blood cholesterol was 178.51 ± 29.12, mean RBS was 135 ± 4.93mg/dl	8 (High)
Togas *et al*., (2014)	Greece	34% were overweight, 13% were obese, 88% were smokers,	Cross sectional	Questionnaire, BMI	100	100	-	-	Mean BMI was 25.68 ± 3.69	7(medium)
Gates & Bradford (2015)	USA	21% were hypertensive, 17% had dyslipidaemia, 5% had diabetes	Retrospective longitudinal study	Data for the study extracted from department of corrections electronic health record and offender management systems.	2932	2715	217	40	Mean weight change was + 0.96kg, mean BMI change was + 0.15.	7(medium)

Van-Doreen *et al*., (2013)	Australia	58.8% were substance dependent, 50.1 % abused alcohol, 8.7% had chronic conditions	Cross sectional	Face to face confidential interviews	376	333	43	22.2	29.2% used > 3 unlawful drugs	5(medium)
Kumar *et al.,* (2013)	India	4% were hypertensive	Cross sectional	Personal interview, clinical examination, anthropometric measurements	300	287	13	-	4% were hypertensive and 0.2% had varicose veins	7(medium)
Vera-Remartínez *et al*., (2014)	Spain	34.8 % had dyslipidaemia, 17.8 % were hypertensive, 5.3% had diabetes, 70.4% were smokers, 39.6% were overweight, 12.3 % were obese,38.5% were sedentary, 17.2% had higher waist circumference, 42% drank > 3 cups of coffee, 30.5% regularly used cocaine and 26.4 were occasional users	Multicentre, descriptive cross sectional study	Interview, anthropometry, clinical analysis, blood pressure	1077	1022	55	37.4		8(High)
Mukhtar *et al.,* (2013)	Pakistan	24.9% were smokers, 75.4% had no fruit intake, 26.4% were overweight, 27.13% were obese,	Cross sectional survey	BMI, interview, questionnaire	269	-	269	35.44± 12.23	Mean BMI was 26.63 ± 5.3, mean cigarettes smoked per day 14.6,	6(medium)

Haysom *et al.*, (2013)	Australia	77.9% were past alcoholics, 76.7% were past smokers, 20.7 % used psychotropic medication, 32.3% were overweight, 15.5% were obese.	Prospective cohort study	Anthropometry, BMI, interview, questionnaire	303	264	39	17.1 ± 1.5		5(medium)
Clarke *et al.*, (2015)	USA	34.9% were overweight, 16.5% were mildly obese, 15.6% were severely obese, 80% smoked before incarceration, 45.6% used alcohol excessively, 85.8% used drugs like heroin, cocaine, opioids, marijuana, 63.6% used more than one substance per day, 34.6% were likely to have an eating disorder, 36.3% were centrally obese	Cross sectional	Weight, height, BMI, waist circumference, interview,	152	-	152	-		7(medium)

Collins & Thompson (2012)	USA	Low fruits and vegetables provision, cholesterol provision in one menu was 448.1mg and in another 504.8mg, sodium provision was 3366.1mg and 3420.9mg in the two different menus, Fibre was 50% below the RDA for the two menus, sugar provision was in excess for one menu at 97.5g/day, one menu provided 650.2mg for calcium and another provided 1328.5mg, vitamin E provision was 4.3 and 6.6, magnesium provision was 219.1 and 273.5, vitamin D provision was 1.3 and 6.2	Menu was obtained from south Carolina Department of corrections and a country detention centre	Information on prison menu obtained via email, interview,	-	-	-	-	Magnesium, potassium, vitamin E, and fibre provided in menu was low	7(medium)

Wolff *et al.*, (2012)		Mean BMI 29.6 SD 6.3 > 70% were overweight or obese,	Cross sectional Survey	Questionnaire, self-reported weight and height, BMI	4204	3986	218	Mean age 33.3 SD 10.3 for males and 36.5 SD 10 for females		8(High)
Bai *et al.*, (2015)	USA	34.7% were obese, 5.1% had diabetes, 64.4% were current smokers, 63.9% had ever used cocaine, crack or injected drug.	Cross sectional	Interview, BMI, review of medical records,	759	387	372	Mean age for women was 35.6, that for males was 33.9		8(High)
Cook *et al*., (2015)	USA	31% of fat was from saturated sources, 467mg of cholesterol, 13g fibre, 75g protein provided was in excess for both male and female, 4542mg of sodium was	A copy of a 28 day cyclical menu was obtained as well as popular items	Portions sizes of foods provided in menu was obtained and nutrient content analyzed	-	-	-	-	Menu provided more than the caloric recommendations for females by 444kcal	7(medium)

		provided,2/3 of RDA for most vitamins and minerals was provided, low vegetable, fruit and diary provison	purchased from commissary.							
Leigey and Johnston, (2015)	USA	34% were overweight, 35.9% were obese	Cross Sectional	Data was collected form the Georgia Department of corrections on line offender database.	458	-	458	56.1	Mean BMI was 28.8	7(Medium)
Silverman –Retana *et al.*, (2015)	Mexico	9.5% were obese, 2.5% were hypertensive, 1.8% were hypertensive, 2.91% of sub sample had metabolic syndrome, 37.9% were sedentary.	Cross sectional	Anthropometry, blood pressure, screening for diabetes.	14086	14086	-	-		8(High)
Jaka *et al*., (2014)	Albania	51.1% were smokers, 34.9% were alcoholics, , 10.2% used drugs,	Cross sectional	Questionnaire	401	290	111	34.1± 7.3		6(medium)
Alves *et al*., (2015)	Portugal	10 had been diagnosed with hypertension, diabetes and high cholesterol levels prior to imprisonment	Cross sectional	Focus groups, semi structured questionnaire	15	-	15	39 ± 12.91	Focus group discussion revealed improvement in the chronic health conditions of inmates.	7(Medium)