THE EFFECT OF RAMADAN FASTING ON BODY ANTHROPOMETRIC MEASUREMENTS, HEMATOLOGICAL INDICES AND SERUM LIPID PROFILE IN GHANAIANS

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL PHYSIOLOGY DEGREE

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DECLARATION

With the exception of duly acknowledged references, I, Tawagidu Mohammed, do hereby declare that this research work was carried out by me at the Department of Physiology, School of Biomedical and Allied Health Sciences, University of Ghana, under the supervision of Dr. Rev. Charles Antwi-Boasiako; Department of Physiology, School of Biomedical and Allied Health Sciences, University of Ghana, Korle-Bu, Accra, Ghana and Dr. Bartholomew Dzudzor; Department of Biochemistry, School of Biomedical and Allied Health Sciences, University of Ghana, Korle-Bu, Accra, Ghana. No part of this thesis has been previously submitted for the award of a degree or any other qualification.

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DEDICATION

I dedicate this work to Allah Almighty and to my wonderful husband (Dr. Kareem Wasiu).
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All thanks be to the Almighty Allah for guiding me in everything that I do and for bringing me this far. My sincere gratitude first of all goes to my supervisors, Dr. Rev. Charles Antwi-Boasiako and Dr. Bartholomew Dzudzor for their wonderful supervisory work. Without their help, this work would not have been a success. I am very grateful for your time. Thank you so much for all the sacrifices you made. God richly bless you.

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LIST OF ABBREVIATIONS

- ANOVA: Analysis of variance
- BASO: Basophils
- BMI: Body mass index
- BP: Blood pressure
- CHD: Coronary heart disease
- CNS: Central nervous system
- DNA: Deoxyribonuclei acid
- EO: Eosinophil
- FBS: Fasting blood sugar
- HCT: Hematocrit blood test
- HDL: High density lipoprotein
- HGB: Hemoglobin
- IGF1: Inhibitory Growth Factor 1
- Kg: Kilograms
- LDL: Low density lipoprotein
- LYMPH: Lymphocytes
- MCHC: Mean corpuscular hemoglobin concentration
- MCV: Mean corpuscular volume
- MG: Methylglyoxal
- ml: Milliliters
- MONO: Monocytes
- NEUT: Neutrophils
• PLT  Platelets
• RBC  Red blood cells
• SD  Standard deviation
• TC  Total cholesterol
• VLDL  Very-low-density lipoprotein
• WBC  White blood cells
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ABSTRACT

Background:

Ramadan is the ninth month of the lunar calendar during which fasting is prescribed for every healthy adult Muslim. Intermittent fasting and caloric restriction, or alternate-day feeding, had been shown to have effect on some physiological and biochemical parameters in the body. Ramadan fasting is considered a unique model of intermittent fasting as food and fluid intake becomes exclusively nocturnal without restriction on the type or amount of food intake. During this fasting period Muslims refrain from food, liquids and smoking during daylight hours and eat a large meal after sundown. This custom provides a unique opportunity to study the hematological and serum lipid profile changes as well as caloric intake over Ramadan time.

Aim

The aim of this study is to determine the effect of Ramadan fasting on hematological indices, caloric intake, lipid profile and anthropometric parameters among Ghanaian Muslims.

Methodology

The study was a prospective study which involved 200 healthy fasting Muslims (83 males and 117 females) recruited from the Sabon Zongo community of Accra within the age range of 15 to 60 years old for 30 days of Ramadan fasting from 6th June to 5th July, 2016. A questionnaire was administered to obtain the demographic data of all participants as well as their diet history. Venous blood samples (5 ml) were drawn from each of the participants pre and post Ramadan fasting. Full blood count was done using Mindray BC- 6800 Auto Analyzer (Sysmex KX21 N, Japan). Lipid profile was determined using the chemistry analyzer. Anthropometric
measurements were obtained using the digital scale and sphygmomanometer was used to obtain blood pressure.

Result

There was a decrease in weight (70.59±18.25 vs 70.01±19.43)kg, percentage body fat (34.04±12.18 vs 33.02±12.36)%, systolic blood pressure (132.32±24.84 vs 130.37±22.06)mmHg and BMI (26.83±7.75 vs 26.39±6.70)kg/m² between the pre- fasting and the fasting periods but the difference was not significant (p= 0.647, 0.466, 0.655 and 0.402 respectively). While percentage muscle mass was found to increase significantly (28.11±6.04 vs 28.25±6.68) following Ramadan fasting with P-value of 0.026. The pre-fasting and fasting white blood cells (3.52± 1.15 vs 3.81 ± 1.91), red blood cells (4.72 ± 0.57 vs 4.54 ± 0.63), hematocrits (41.86 ± 4.77 vs 42.59 ± 6.77) and hemoglobin (12.67 ± 1.74 vs 15.17 ± 19.74) levels show no statistically significant changes with P-value of 0.377, 0.176, 0.557 and 0.419 respectively.

There was a decreased total caloric intake with increased fatty food intake (160.65 ± 152.24 and 198.32 ± 353.16) following. Also a statistically significant increase was observed in all the lipid profile parameters following fasting TC (3.10 ± 0.45 vs 4.25± 0.87), HDL (1.31 ± 0.17 vs 1.55 ± 0.20), LDL (1.62 ± 0.41 vs 2.30 ± 0.86) and TG (0.592 ± 0.121 vs 0.791 ± 0.231) with P-value of <0.001, <0.001, 0.001 and <0.001 respectively.

Conclusion

It is concluded from this study that even though Ramadan fasting decreases weight, percentage body fat, BMI, hematological changes the effect was not significant. Whereas the percentage muscle mass, blood pressure, low density lipoprotein, high density lipoprotein, triglycerides, total cholesterol and fatty food intake were increased significantly during Ramadan fasting in
Ghanaian Muslims. This study reports the primary data on the effect of Ramadan fasting on hematological indices, caloric intake, lipid profile and anthropometric parameters among Ghanaian Muslims.
CHAPTER ONE

INTRODUCTION

1.1 Background

Fasting is considered to be a healthy practice in many cultures and religions. Ramadan is the ninth month of the lunar calendar of Muslims during which fasting is prescribed for every healthy adult Muslim (Khaled et al., 2012). Fasting during the month of Ramadan is one of the five fundamental rituals (pillars) of Islam (Lahdimawan et al., 2013).

During Ramadan, all Muslims are expected to abstain daily from food, drinks and smoking from dawn to dusk and this duration is variable according to season and geographical location. Fasting during Ramadan ranges from 11 to 18 hours a day (Khaled et al., 2012; Lahdimawan et al., 2013). The uniqueness of Ramadan fasting is that food and fluid intake is concentrated into the hours between sunset and the following sunrise. There is a change in circadian rhythm of the body from diurnal to nocturnal. Constant restriction on eating and drinking schedule during the month of Ramadan can influence substrate availability and utilization and hence can induce changes in hematological and biochemical parameters in the body (Khaled et al., 2012).

Intermittent fasting and caloric restriction, or alternate-day feeding, had been shown to increase resistance to toxicity and stress and to prolong maximum life span in experimental animals and humans (Martin et al., 2006; Varady and Hellerstein, 2007). Ramadan fasting is considered a unique model of intermittent fasting (Aksungar et al., 2005), as food and fluid intake becomes exclusively nocturnal without restriction on the type or amount of food intake. Ramadan fasting is associated with alteration in meal frequency, sleep duration, and reduction in physical activity.
during the day (El Ati et al., 1995). Many physiological and psychological changes are observed during Ramadan fasting (Aksungar et al., 2005). Despite the marked changes in food intake habits, some studies showed that Ramadan fasting has no effect on body weight or body mass index (BMI) (El Ati et al., 1995; Aksungar et al., 2005; Lamri-Senhadji et al., 2009), while other studies reported that Ramadan fasting is associated with significant weight loss (Ziaee et al., 2006; Mansi, 2007; AlHourani and Atoum, 2007).

Based on the established relationship between body weight and caloric intake, a study to assess physiological changes, hematological changes and serum lipid profile in Ghanaian Muslims during the Ramadan fasting becomes very imperative. Hence the focus of the current study.

1.2 Problem statement

Ramadan fasting is observed by millions of Muslims all over the globe. The modification in eating and sleeping pattern may affect various aspects of the human health. Also, the possible consequences of modification in food intake schedule during Ramadan fasting on public health have not been extensively documented. There is a controversy in existing literature about the lipid profile of Muslims during Ramadan fasting. Some studies have reported a significant decrease in serum total cholesterol (TC) and triglycerides (TG), with significant increase in high density lipoprotein (HDL) following (Adlouni et al., 1997). Other studies have also reported no change in low density lipoprotein (LDL) and TC with decrease in the LDL/HDL and TC/LDL ratio following Ramadan fasting (Kul et al., 2014). There is therefore the need to carry out this study to confirm the effect of Ramadan fasting on lipid profile in Ghanaian Muslims. Also, physiological changes during Ramadan fasting are not very well known and work done concerning the effect of Ramadan fasting are very few and with conflicting results.
The reduction in body weight during Ramadan fasting in connection with body fat is also not well known. Research done by Mansi, (2007) came out with the findings that Ramadan fasting leads to a significant decrease in weight and BMI. This contradicted work done by El Ati et al., (1995) as they recorded no significant change in weight and BMI. Studies on the effect of Ramadan fasting on hematological profile have revealed various contrasting results. Al Tufail et al., (1992) in their work recorded no change in hematological indices. However, Salehi et al., (2000) recorded some slight decrease in hematological indices. These contrasting results cannot help in drawing conclusions on the effect of Ramadan fasting in Ghanaians and not much work has been done to find out the effect of Ramadan fasting on the health of Ghanaians. Therefore, there is the need to study the physiological effects of Ramadan fasting on Ghanaian Muslims.

1.3 Justification

The effect of Ramadan on physiological parameters, hematological indices and serum lipid profile is still a matter of debate. Some studies have shown that Ramadan fasting has no effect on physiological and biochemical parameters while other studies showed an association. Therefore, there is the need for this study to investigate its beneficial or adverse effects on Ghanaian Muslims. Although some studies have reported the effect of Ramadan fasting on hematological indices and serum lipid profile, the recorded results have not been consistent. There is also scarcity of work on the effect of Ramadan fasting on hematological indices and serum lipid profile in apparently healthy individuals especially in Ghanaians. This study would help provide baseline data on the effect of fasting on Ghanaian Muslims and by extension the etiology of certain diseases in Ghanaian Muslims.
1.4 Aim

The aim of this study was to determine the effect of Ramadan fasting on body anthropometric measurements, hematological indices and serum lipid profile among Ghanaian Muslims.

1.4.1 Specific objectives

To determine the effect of Ramadan fasting on;


2. Serum lipid profile such as HDL, LDL, TC and TG and hematological indices such as Hemoglobin, white blood cells, MCHC, MCV and red blood cells among Ghanaian Muslims.

3. Dietary profile of Ghanaian Muslims.
CHAPTER TWO

LITERATURE REVIEW

2.1 Fasting

Fasting in humans is said to be achieved by ingesting no or minimal amount of food and caloric beverages for periods of about twelve (12) hours to three (3) weeks. Many religious groups and cultures have incorporated periods of fasting into their rituals including Muslims, who fast from dawn until dusk during the month of Ramadan, and Christians, Jews, Buddhists, and Hindus, who traditionally fast on designated days of the week or calendar year. Currently, patients are being monitored by physicians while undergoing water only fasting or very low calorie fasting lasting for one (1) week or longer for weight management and for disease prevention and treatment (Longo and Mattson, 2014).

2.1.1 Types of fasting

Trepanowski and Bloomer, (2010) classified fasting into four types. These are the caloric restriction form of fasting, the alternate- day fasting, dietary restriction form of fasting and religious fasting. The religious fasting includes the Islamic Ramadan fasting, the three principal fasting period of the Greek Orthodox Christianity (navity, lent and assumption) and the Biblical-based Daniel fast.

2.1.2 Ramadan fasting

Ramadan is the ninth month of the Islamic lunar calendar during which fasting is prescribed for every healthy adult Muslim (Khaled et al., 2012). Fasting during Ramadan is one of the five fundamental rituals (pillars) of the Islamic faith. It is stated in the Noble Qur’an that “O you who believe! Fasting is prescribed to you as it was prescribed to those before you so that you can
learn Taqwa (good deeds and God-consciousness)” (Quran 2: 183). During this period of fasting, all Muslims must abstain daily from food, drinks and smoking from the period between dawn to dusk and also to abstain from sexual relationship and any forms of misconduct and also from consuming medicines, nutritional fluids and from all addictions (Ahmad et al., 2012). Ramadan fasting is observed by over 400 million Muslims spread across the globe and Muslims living under various geographical, climatic, social, cultural and economic conditions. The period of fasting during Ramadan is variable according to season and geographical profile and can range from 11 to 18 hours a day (Khaled et al., 2012; Lahdimawan et al., 2013), with a duration of 29 to 30 days (Trepanowski and Bloomer, 2010). Fasting during the month of Ramadan is obligatory for every healthy adult Muslim but, when fasting turns out to significantly affect the health of the fasting individual or when an individual is genuinely sick, Islam exempts him or her from the Ramadan fasting. It is stated in Qur’an that, “Allah does not impose upon any soul a duty but to the extent of its ability” (Quran 2: 286). Fasting during Ramadan is also not obligatory for children, travellers, pregnant women, breast feeding mothers, menstruating women or the debilitated (Azizi, 2002; Khaled et al., 2012). Menstruating women as well as sick and travelling people, pregnant and lactating women are permitted to postpone the fasting during Ramadan. However, they are expected to fast during another month of the year, when they have no reason for exemption to make up for the lost times (Azizi, 2002).

The basic objectives of this month long fasting process are to help shape the behaviour and pattern of life of its practitioners in such a way that they turn out to be ideal beings. In order to achieve this, a fasting individual must restrain him or herself listening, speaking, hearing or thinking bad of others (Ahmad et al., 2012).
The uniqueness of Ramadan fasting is that food and fluid intake is concentrated into the hours between sunset and the following sunrise. Fasting has been shown to have a positive effect on longevity (Khaled et al., 2012).

During Ramadan fasting, only two meals are taken daily and also, the total daily amount of food decreases. Therefore, Ramadan can have anthropometric, physiological, metabolic and endocrine effects on the human body (Sayyedda et al., 2013). Ramadan teaches Muslims self-restraint and reminds a Muslim of the feelings of the impoverished (AlNahari and Kouja, 2014). During the month of Ramadan, frequency and quantity of food and daily physical activity are changed. Food and fluid intake are mainly nocturnal. The food habits, as well as food quality, differ during Ramadan fasting as compared with other months. There is tendency to consume foods that are richer in carbohydrates during this period (Baltaci and Bucaktepe, 2011). The Ramadan fasting is associated with altered meal patterns and sleep (Lahdimawan et al., 2013).

As part of the aims of Ramadan fasting, Muslims are encouraged to be mindful of their health. Islam encourages individuals to do their best to keep up healthy living lifestyle including having healthy balanced diet. Ramadan fasting then becomes a great opportunity for Muslims to focus on returning to a balanced and healthy lifestyle. Through Ramadan fasting one begins to learn how to manage eating habits, how to improve self-control and discipline. During this Ramadan fasting period, the stomach is able to break down and get rid of accumulated toxins from the body as its work load is reduced (Mahroof et al., 2007).

2.1.3 Intermittent fasting

Intermittent fasting has been found to help extend life-span, decrease age-related health diseases and decrease the development of chronic degenerative diseases (Martin et al., 2007). Genetically,
the human system is adapted cycles of feast and famine, and physical activity and rest. These cycles are beneficial in modulating metabolic processes in the human body and without these cycles, the human system becomes prone to metabolic derangements such as obesity and diabetes. Intermittent fasting puts the human system in the feast and famine cycle and therefore the need for intermittent fasting (Halberg et al., 2005).

Intermittent fasting is known to be an excellent weight loss regimen that has received extensive attention in recent times. Intermittent fasting can produce excellent decreases in coronary heart disease (CHD) risk, and this is mediated in part by improvements in adipokines (Kroeger et al., 2012). Ramadan fasting can be considered to be a type of intermittent fasting, in which there are periods of fasting and feasting (Longo and Mattson, 2014).

Tajes et al., (2010), carried out a research and came out with a finding that, after eight weeks of intermittent fasting, antioxidant control of oxidative stress was significantly improved.

Intermittent fasting also helps to protect against metabolic toxins (Steinshraus et al., 2008). It helps to lower serum glucose levels, increase insulin sensitivity, increase HDL levels, improves the cholesterol and HDL ratio, lowers homocysteine levels and helps to manage diabetes (Hfaiedh et al., 2008., Aksungar et al., 2005). Intermittent fasting has also been found to improve protein metabolism and it controls blood pressure (Halberg et al., 2005).

Adiponectin, which is a protein hormone known to regulate blood glucose and blood fat metabolism and controls body fat, has been found to increase during intermittent fasting (Tikoo et al., 2007).

Intermittent fasting has been shown to also help in lowering growth hormone and increasing Inhibitory Growth Factor 1(IGF1) levels. This helps to protect against the ageing process.
Intermittent fasting has been found to protect against neurodegenerative disorders. Intermittent fasting has also been found to suppress Methylglyoxal (MG) formation which is a glycating agent that is associated with impaired energy production, oxidative stress, and abnormal gene expression and cell signaling (Rocha et al., 2002).

2.2 Physiological changes that occur during a fast

Changes in the body physiology occur in response to fasting depending on the length of the fast. The body is said to be in a state of fasting eight hours or more after the last meal. During this period, digestion and reabsorption of nutrients would have taken place. In the non-fasting state, body glucose, which is stored in the liver and muscles, is the body’s main source of energy. However, during fasting, glucose stores get depleted. The body then resorts to the use of fat to generate energy (Mahroof et al., 2007). Protein becomes a source of energy only when there is prolonged fasting of many days to weeks. This then becomes an unhealthy practice. As the Ramadan fasting only extends from dawn till dusk, there is that opportunity to replenish energy stores at dawn and after sunset. This cycle of feeding then becomes a progressive transition from the use of glucose to fat as the main source of energy and thus prevents the breakdown of muscle for protein. The use of fat for energy is very beneficial as it aids in weight loss. It also helps to preserve the muscles and in turn, improves blood cholesterol levels. In addition, weight loss results in better control of diabetes and reduces blood pressure. Fasting also aids to improve level of alertness and general mental well-being. This is achieved as fasting helps to elevate levels of endorphins (Mahroof et al., 2007).

2.3 Energy requirements during Ramadan fasting

The balance of food and fluid intake between fasting is very important. The kidney functions in maintaining a balance in the body’s fluids and electrolytes. However, these can be lost through
sweating. There is also the tendency for the breakdown of muscles during fasting to provide energy. In order to prevent muscle breakdown, meals must contain adequate levels of “energy food”, such as carbohydrates and some fat. Hence, a balanced diet with adequate amounts of nutrients, salts and water is vital (Zechner et al., 2005).

A diet with less than a normal amount of food but is sufficiently balanced can keep a person healthy and active during the month of Ramadan. The diet during Ramadan fasting should be simple and not differ much from an individual’s normal everyday diet (Zechner et al., 2005).

The blessed Prophet said: “The children of Adam fill no vessel worse than their stomach. Sufficient for him is a few morsels to keep his back straight. If he must eat more, then a third should be for his food, a third for his drink, and a third left for air” (Sunan al-Tirmidhî). The Quran mentions that, “Eat and drink freely: but waste not by excess, for Allah does not like the wasters (Quran 7: 31).” Fasting in the month of Ramadan then becomes an opportunity to make significant changes in one’s lifestyle and develop the habit of making healthy living choices. Ramadan fasting teaches people to manage and not to over-eat. Thus fasting during Ramadan helps a person to choose a healthier lifestyle by making small yet lasting changes to their daily diet and not to make it feasting periods (Zechner et al., 2005).

2.4 Health benefits of fasting

Constant restriction on the eating and drinking schedule may have an effect on the body’s biochemical and physiological function (Khaled et al., 2012). Ramadan fasting has been reported to have physiological effects on the body, especially in relation to changes in blood pressure, lipids, apoproteins, fasting blood sugar (FBS), hormones and other biochemical parameters (Sarraf-Zadegan et al., 2000). Fasting is considered to be a healthy practice in many cultures and
religions. Modern laboratory studies have shown a positive effect of fasting on longevity (Baltaci and Bucaktepe, 2011). Fasting was used as a therapy for the management of diabetes from 1913 until the first use of insulin in 1922 (Lignot and Lemaho, 2012).

Dietary changes during Ramadan can influence substrate availability and utilization and induce changes in hematological and biochemical parameters in the body (Khaled et al., 2012). The study by Baltaci and Bucaktepe, (2011), demonstrated that Ramadan fasting can lead to some beneficial changes in blood pressure and some inflammatory markers, as well as metabolic and anthropometric measurements in obese persons. They also demonstrated that fasting in general has been used in medicine for several medical reasons, including weight management, for rest of the digestive tract, and for lowering lipid levels. They also reported that fasting may have some adverse effects, such as effects of so-called crash diets. However, Ramadan fasting is different from such diet plans, because in Ramadan fasting, there is no malnutrition or inadequate caloric intake. The caloric intake of Muslims during this period of Ramadan is at or slightly below the normal requirements. The body has regulatory mechanisms that are activated during fasting. There is efficient utilization of fat and slow basal metabolism during fasting. Ramadan fasting has beneficial results on our metabolic and anthropometric measurements, especially insulin resistance and body mass index (BMI) (Baltaci and Bucaktepe, 2011).

Heart rates and blood pressures are normalized during the first few days of fasting (Azizi, 2002). It is well known that a given nutrient ingested at an unusual time can induce different metabolic effects. It is well established that lipid profile is affected by dietary habits, percentage of fat in the daily diet and its saturation, and amount of exercise. Since food intake during Ramadan is decreased, Ramadan can be said to be a form of diet program. It has been reported in the literature that the serum high-density lipoprotein cholesterol (HDL-C) level is increased and the
low-density lipoprotein cholesterol (LDL-C) level is decreased due to Ramadan fasting (Baltaci and Bucaktepe, 2011). There is also an increase of the total blood cholesterol, High density lipoprotein (HDL) with a decrease in Low density lipoprotein (LDL). These changes could be beneficial for the cardiovascular system as HDL is protective against coronary heart disease (Roky et al., 2004).

Fasting in Ramadan has been shown to have some effects on the circulating levels of several biochemical markers known to be associated with vascular and metabolic disorders. It also has an effect on serum lipid profile. It is known that lipid profile is influenced by dietary habits, physical factors, percentage body fat, type of fat saturation, and the percentage of simple sugars in the daily diet and weight loss. Other lifestyle changes such as the more frequent and voluntary prayers performed during Ramadan which can be compared to moderate exercise, may lead to a healthier outcome (AlNahari and Kouja, 2014).

There is usually a slight decrease in body weight as a result Ramadan fasting and this can be attributed to decreased fluid intake (Roky et al., 2004). Ramadan fasting is beneficial in that, it helps in significant reduction in weight, body mass index, waist circumference and anxiety in people who fast. Blood pressure is not significantly affected during Ramadan fasting (Saiyad et al., 2014).

Ramadan fasting can serve as a healthy non pharmacological means for improving cardiovascular risk factors (Longo and Mattson, 2014).

In lower eukaryotes, chronic fasting has been found to extend longevity by reprogramming metabolic and stress resistance pathways. It was also found that in rodents, intermittent or periodic fasting may protect against diabetes, cancers, heart disease, and neurodegeneration. In
humans, fasting helps reduce obesity, hypertension, asthma, and rheumatoid arthritis. Fasting has the potential to delay ageing and helps prevent and treat diseases while minimizing the side effects caused by chronic dietary interventions (Longo and Mattson, 2014).

Fasting helps to stimulate antioxidant release in the body which aid in protection of the human body against damage caused by free radicals (Gilca et al., 2007).

2.5 Ramadan fasting and carbohydrate metabolism
The effects of short-term fasting on carbohydrate metabolism have received extensive attention (Heber, 2001). During the period of fasting, the body begins to adapt to the state of starvation within 8 to 16 hours. During this period of starvation, there is a metabolic importance which involves the provision of adequate glucose to the brain cells, red blood cells, peripheral nerves and renal medulla. This then leads to a slight decrease in serum glucose from about 3.3 to 3.9 mmol/L (60-70 mg/d L) within a few hours of fasting in normal adults. This fall in serum glucose usually ceases due to a breakdown of glycogen and increased gluconeogenesis, as well as a decrease in both glycogen synthesis and glycolysis in the liver (Azizi, 2002). There is also a decrease in insulin levels in the blood with a rise in catecholamine concentrations. These eventually result in lipolysis of adipose tissues and a rise in the level of free fatty acids. These free fatty acids serve as a source of energy for the body tissues in place of glucose (Heber, 2001).

2.6 Ramadan fasting and lipid metabolism
There has been controversy in literature concerning the effect of Ramadan fasting on serum lipid levels with variable results. A fall in serum cholesterol may be seen within the first few days of fasting slightly above the pre-fasting levels (Azizi, 2002). Some studies reported a rise in serum cholesterol, which may probably be related to weight loss during Ramadan fasting. However,
other studies have found no change in serum cholesterol levels (Maislos et al., 1993; Maislos et al., 1998) and also decreased levels of total serum cholesterol during fasting (Aziz, 1996; Temizhan et al., 2000; Adlouni et al., 1997). Some studies also reported appreciable increase in plasma HDL following Ramadan fasting (Maislos et al., 1993; Adlouni et al., 1997). Changes in blood lipids might be dependent on the quality and quantity of food consumption. These changes may also be related to the consumption of large meals, as lipid levels increase with taking one large meal per day (Azizi, 2002) although, this has not been confirmed in fasting during Ramadan (Maislos et al., 1998).

2.7 Ramadan fasting and the cardiovascular system

Prolonged fasting is suggested to cause bradycardia and hypotension in fasting individuals (Kadiri et al., 2001). However, heart rate and blood pressure remain normal within the first few days of fasting. Literature has found no contraindications to observing fasting in patients with valvular problems or mild coronary artery disease. However, it has been assumed that Ramadan fasting does not increase acute coronary artery disease events. Therefore fasting is safe (Temizhan et al., 1999).

2.8 Ramadan fasting and the gastrointestinal tract

Fasting causes a fall in gastric secretions. It is known that gastrointestinal tract movements occur every two hours. It begins from the stomach towards the duodenum, jejunum and ileum, getting rid of all food debris (Azizi, 2002). The gallbladder empties less frequently in fasting state than in the fed state. Fasting has been postulated to aid in the healing of duodenal ulcer (Mehdi and Ajmi, 1997). Fasting may be very beneficial in patients with spastic colitis and some other intestinal motility disorders as fasting decreases intestinal contractility (Azizi, 2002).
2.9 Ramadan fasting and the kidney

During Ramadan fast, urine volume, pH, nitrogen, solute and electrolyte excretion remain within the normal range (Cheah et al., 1990). There are no statistically significant changes in serum urea and creatinine (Azizi, 2002). Intermittent fasting may lead to a slight increase in uric acid and therefore has no significant alterations in serum sodium and potassium (Azizi, 2002).

2.10 Ramadan fasting and pregnancy and lactation

Starvation in pregnant women may result in decreased blood glucose. Animal experiments showed that starvation leads to compensation in fetal energy source. A study done in pregnant women in Gambia who were fasting had no satisfactory results. A significant fall in glucose, insulin, lactate and carnitine and a rise in triglycerides and hydroxybutyrate were reported at the end of the day’s fasting in these pregnant women (Azizi, 2002).

It is documented that lactating mothers who fast may lose their body fluids with changes in plasma osmolality, sodium, and uric acid, and in lactose, sodium, and potassium content of the breast milk. Starvation in pregnancy may also cause some alterations later in the life of the child. This indicates that until further studies are undertaken, pregnant women should avoid fasting in Ramadan (Azizi, 2002).

2.11 Ramadan Fasting and hematological changes

Hematological changes during the Ramadan fasting have been found to have conflicting results. Some studies showed no changes in the hematological parameters, while others reported slight changes, such as a decrease in hemoglobin and T-lymphocyte cells (Roky et al., 2004). Ramadan fasting has no statistically significant changes in hemoglobin, red blood cell indices,
and white blood cell count but with decreased serum iron levels and total iron-binding capacity, indicating that iron stores are not significantly disturbed (Azizi, 2002).

2.12 Effect of Ramadan fasting on physiological factors

The changes in eating habits, sleep and physical activities during Ramadan fasting may lead to some physiological changes in the body. Fasting in Ramadan can cause changes in the body components such as a significant decrease in body weight, body mass index, glucose and percentage body fat (Hosseini et al., 2013). Physiological changes during Ramadan fasting are not very well known and work done concerning the effect of Ramadan fasting are very few. Fasting during Ramadan is a radical change in lifestyle for the period of a lunar month, and lifestyle change has a significant impact on cardiovascular system. There are findings that heart rate parameters increase in the month of Ramadan and also Ramadan fasting enhances the parasympathetic activity (Meo and Hassan, 2015). During Ramadan fasting, there is the use of fat for energy. This aids in weight loss and weight loss helps in better management of diabetes and reduces cholesterol levels and blood pressure (Mahroof et al., 2007). The physiological effects of fasting include lowering of blood sugar, lowering of cholesterol and lowering of the systolic blood pressure. Ramadan fasting has been suggested to be an ideal recommendation for treatment of mild to moderate, stable, non-insulin diabetes, obesity and essential hypertension (Ahmad et al., 2012).

2.13 Fat metabolism

When food is taken in abundance, mammals preferentially burn carbohydrates to generate energy. The excess glucose, after replenishing glycogen stores, is converted to fatty acids and then used in the synthesis and storage of TG in white adipose tissue. White adipose tissue functions as a limitless reservoir to accumulate TG. The liver is also able to store significant
quantities of lipids in conditions associated with prolonged excess energy consumption. In fasted states, when glucose availability and insulin levels are low, there is a depletion of hepatic glycogen stores and a reduction in fatty acid production. TGs stored in adipose tissues are then hydrolyzed to free fatty acids and transported into plasma to the liver. In the liver, the free fatty acids undergo oxidation and converted to ketone bodies to be used as source of energy (Reddy and Rao, 2006).
CHAPTER THREE

METHODOLOGY

3.1 Study design
The study was a prospective study which involved 200 healthy fasting Muslims (83 males and 117 females) recruited from the Sabon Zongo community of Accra within the age range of 15 to 60 years old for 30 days of Ramadan fasting from 6th June to 5th July, 2016.

3.2 Study site
The study was conducted at the Sabon Zongo community in Greater Accra Region of Ghana. The Sabon Zongo community is a suburb of Accra located in Accra West and in Ablekuma central sub-metro. It is a highly Muslim populated community of about thirty thousand (30,000) inhabitants. It shares boundaries with Abossey-Okai and Lartebiokorshie. The demographics of the study participant that were enrolled in this study were not limited to a specific social group.

3.2.1 Study population
This study involved healthy male and female Muslims taking part in the Ramadan fasting for 30 days from 6th June to 5th July, 2016 with age range of 15 to 60 years. A questionnaire was administered to obtain the demographic data of all participants as well as their diet history (Appendix II).

3.2.2 Inclusion criteria
All healthy male and female Muslims in the Sabon Zongo community taking part in the Ramadan fasting within the age range of 15 to 60 years during the stated period.
3.2.3 Exclusion criteria

Muslims who are not taking part in the Ramadan fasting.

3.3 Recruitment of participants

Permission was sought from the Chief and Imaams of the Sabon Zongo community in Accra. Talks were given in the mosques to inform the people about the study. Names and contacts of interested persons were documented. Follow-ups were made to the various homes of the interested persons to further explain the purpose of the study. The dates for the study were also made known to the interested persons. On the day of the study, the interested participants merged at the main mosque in the community and the study was carried out.

3.4 Sample size determination

The minimum number of study participants that were enrolled for this study was obtained using the formula \( n > \frac{Z^2 \cdot (P) \cdot (1-P)}{E^2} \).

Where

- \( n \) is the sample size
- \( Z \) is the standard score for the confidence level = 1.96
- \( P \) is the population proportion
- \( E \) is the allowable error

When \( P \) is unknown, 0.5 is used for the sample proportion. At 95% confidence level and significant level of 5%, \( Z \) score is 1.96. At an allowable error of 0.07, a sample size of 196 was obtained. This value was rounded up, giving a total sample size of 200.
3.5 Data collection tools

- Questionnaire
A questionnaire was used to obtain demographic data and diet history of the participants.

- Digital scale
The digital scale was used to measure the weight, BMI, percentage body fat, visceral fat and percentage muscle mass of the participants.

- Sphygmomanometer
The blood pressure of each participant was measured using the sphygmomanometer.

- Height meter
The height meter was used to measure the height of each participant.

- The Mindray BC- 6800 Auto Hematology Analyzer
It is a quantitative, automated hematology analyzer for in vitro diagnostic use in clinical laboratories. It provides complete blood count, leukocyte 5-part differential, hemoglobin concentration measurement, reticulocyte and nucleated red blood cell measurement.

3.6 Collection of blood samples
Venous blood samples (5 ml) were drawn from each of the consented participants 3 days (3rd June) to the start of the fasting and on the 27th day (2nd July) of the Ramadan fasting into plain tubes and EDTA tubes and transported to the laboratories in an ice-chest for analysis. The samples in the plain tubes were centrifuged and the serum kept at -20°C until analyzed. The samples in the EDTA tubes were sent to the laboratory for hematological analysis.
3.7 Sample analysis

3.7.1 Full blood count

Samples taken for the full blood count analysis were analyzed within three hours of collection. The Mindray BC-6800 Auto Hematology Analyzer (Sysmex KX21 N, Japan) was used for the full blood count analysis.

3.7.2 Lipid profile analysis

Measurement of serum total cholesterol and serum triglyceride: Three hundred microliters (300µl) of cholesterol reagent (ELITech Clinical Systems, France) was pipetted into a cuvette and three microliters (3µl) of participant’s serum added. It was then well mixed and incubated for 5 minutes at room temperature. The intensity of the pink colour formed was measured at 500nm and the readings (absorbances) recorded.

Measurement of high density lipoprotein (HDL) and low density lipoprotein (LDL): Two hundred and forty microliters (240µl) of HDL direct reagent (R1) (ELITech Clinical Systems, France) was pipetted into a cuvette and 2.4µl of participant’s serum added. It was also well mixed and incubated for 4 minutes at room temperature. Absorbance A1 was measured. 80 µl of HDL and LDL direct reagent (R2) was then added and well mixed again. It was incubated for 4 minutes at room temperature and absorbance A2 measured. The concentration of HDL and LDL was the difference in absorbances A1 and A2.

3.8 Dietary analysis

A 24-hour questionnaire was used to obtain the dietary history of each participant. Daily dietary intake of each participant was analyzed using the Ghana Dietetics Association Standard Serving Sizes protocol (Appendix II).
3.9 Definition of the term fasting

Fasting is when one has fasted till the 27th day of the Ramadan fasting.

3.9.1 Definition of pre-fasting

Pre-fasting is the period 3 days to the start of the Ramadan fasting.

3.10 Data analysis

Data was analyzed using SPSS version 20.0 software. Descriptive statistics was used to summarize the data. All values were expressed as mean (M) ± standard deviation (SD) [M±SD]. The differences between the two groups of subjects were analyzed statistically using the paired t-test. Statistical significance was defined as p<0.05.

3.11 Ethical issues

Approval

Ethical approval was sought from the Ethical and Protocol Review Committee, College of Health Sciences, University of Ghana.

Voluntary written informed consent

Voluntary written informed consent and permission for drawing of blood samples was sought from the participant. Prior to initiating this protocol, the method and the objectives of the study were explained to the study participants. All explanations and consent procedures were in English (the official language of Ghana) and the local dialect spoken by the particular participant. Points emphasized were the freedom to decline to participate at any time and the risks and benefits of participating (Appendix I).
Confidentiality

All data were handled anonymously and confidentially. Survey questionnaire, clinical and laboratory data sheets were completed and signed by study investigator only, stored in bound folders while in use, and then secured in locked metal file cabinets or trunks until data entry. Data were doubly entered and checked for entry and range errors. During data entry and validation, database files were accessible by study investigator and supervisors only, and password protected. All samples only had the identifying number of the enrolled participants, and not their names.
CHAPTER FOUR

RESULTS

4.1 Demographic characteristics of study participants

A total of 200 Muslim volunteers undergoing a 30-day Ramadan fasting were recruited for this study. They consisted of 83 (41.5%) males with a mean age of 49.2 ± 19.0 years and 117 (58.5%) females with a mean age of 41.9 ± 17.5 years. One hundred and nineteen (119) (59.5%) of the study participants were married and 98 (49.0%) of them had primary education. Forty one (41) (20.5%) participants had no formal education and only a few (11) (5.5%) had tertiary education (table 1).

Table 1: Demographic characteristics of study participants.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEX</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>83 (41.5)</td>
</tr>
<tr>
<td>Female</td>
<td>117 (58.5)</td>
</tr>
<tr>
<td>MARITAL STATUS</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>61 (30.5)</td>
</tr>
<tr>
<td>Married</td>
<td>119 (59.5)</td>
</tr>
<tr>
<td>Divorced</td>
<td>5 (2.5)</td>
</tr>
<tr>
<td>Widowed</td>
<td>15 (7.5)</td>
</tr>
<tr>
<td>EDUCATION</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>41 (20.5)</td>
</tr>
<tr>
<td>Primary education</td>
<td>98 (49.0)</td>
</tr>
<tr>
<td>Secondary education</td>
<td>50 (25.0)</td>
</tr>
<tr>
<td>Tertiary education</td>
<td>11 (5.5)</td>
</tr>
</tbody>
</table>
4.2 Comparing anthropometric measurements of study participants pre-fasting and fasting

Although no statistically significant difference was found between pre-fasting and fasting weight, percentage body fat, systolic blood pressure and BMI; muscle mass was found to increase by about 0.5% during fasting while weight, systolic blood pressure and BMI decreased (Table 2).

Table 2: Anthropometric measurements of study participants.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD Pre-fasting</th>
<th>Mean ± SD Fasting</th>
<th>Percentage change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>70.596±18.252</td>
<td>70.010±19.433</td>
<td>-0.830</td>
<td>0.443</td>
</tr>
<tr>
<td>BFAT (%)</td>
<td>34.043±12.177</td>
<td>33.016±12.355</td>
<td>-3.111</td>
<td>0.647</td>
</tr>
<tr>
<td>MMASS (%)</td>
<td>28.114±6.043</td>
<td>28.251±6.681</td>
<td>0.485</td>
<td>0.466</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>132.317±24.842</td>
<td>130.366±22.059</td>
<td>-1.474</td>
<td>0.655</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.827±7.750</td>
<td>26.388±6.704</td>
<td>-1.636</td>
<td>0.402</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant
BFAT= percentage body fat
MMASS= percentage muscle mass
SBP= systolic blood pressure
BMI= body mass index
SD= standard deviation
4.3 Comparing hematological indices of study participants pre-fasting and fasting

Hemoglobin, white blood cells, hematocrits, mean corpuscular volume (MCV) and lymphocytes were found to increase post fasting while red blood cells and mean corpuscular hemoglobin concentration (MCHC), monocytes, eosinophil and basophils decreased (Table 3).

**Table 3: Hematological indices of study participants.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD Pre-fasting</th>
<th>Mean ± SD Fasting</th>
<th>Percentage change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC (10⁹/L)</td>
<td>3.518 ±1.149</td>
<td>3.808±1.912</td>
<td>8.249</td>
<td>0.377</td>
</tr>
<tr>
<td>RBC (10¹²/L)</td>
<td>4.721±0.567</td>
<td>4.541±0.631</td>
<td>-3.817</td>
<td>0.176</td>
</tr>
<tr>
<td>HGB (g/dL)</td>
<td>12.656±1.737</td>
<td>15.168±19.737</td>
<td>19.850</td>
<td>0.419</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>41.863±4.769</td>
<td>42.593±6.769</td>
<td>1.742</td>
<td>0.557</td>
</tr>
<tr>
<td>MCV(µm³)</td>
<td>86.744±15.575</td>
<td>95.851±9.211</td>
<td>10.499</td>
<td>0.001*</td>
</tr>
<tr>
<td>MCHC (g/dL)</td>
<td>30.215±1.917</td>
<td>28.046±2.106</td>
<td>-7.177</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>LYMPH (10⁹/L)</td>
<td>2.119±0.980</td>
<td>2.294±1.137</td>
<td>8.262</td>
<td>0.435</td>
</tr>
<tr>
<td>MONO (10⁹/L)</td>
<td>0.247±0.189</td>
<td>0.186±.245</td>
<td>-24.686</td>
<td>0.170</td>
</tr>
<tr>
<td>EO (10⁹/L)</td>
<td>0.115±0.091</td>
<td>0.040±0.088</td>
<td>-59.269</td>
<td>0.002*</td>
</tr>
<tr>
<td>BASO(10⁹/L)</td>
<td>0.024±.0184</td>
<td>0.005±0.008</td>
<td>-80.913</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant

WBC= white blood cells (2.60 – 8.5)  MCV= mean corpuscular volume (76.0 – 96.0)
RBC= red blood cells (3.50 – 5.50)   Lymphocytes (1.00 – 3.00)
HGB=hemoglobin (11.50 – 18.0)        MONO= monocytes (0.2 -1.00)
HCT=hematocrit (36.0 – 54.0)         EO= eosinophil (0.04-0.40)
BASO= basophils (0.02 – 0.10)        MCHC= mean corpuscular hemoglobin concentration (31.0 – 36.0)
4.4 Dietary analysis of study participants pre- fasting and fasting

A decrease in carbohydrate and protein consumption with a decreased total daily caloric intake in fasting as compared to pre-fasting levels was observed. However, fat intake was found to increase by almost 24%. Pre-fasting and fasting dietary consumptions showed no statistically significant values although there were some of the changes in dietary intake (Table 4).

Table 4: Dietary analysis of study participants.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-fasting</th>
<th>Fasting</th>
<th>Percentage change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate (g)</td>
<td>1486.207±1765.064</td>
<td>1264.530±586.779</td>
<td>-14.916</td>
<td>0.414</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>160.463±152.242</td>
<td>198.320±353.157</td>
<td>23.592</td>
<td>0.439</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>81.409±64.847</td>
<td>79.290±60.863</td>
<td>-2.604</td>
<td>0.375</td>
</tr>
<tr>
<td>Total calories (g)</td>
<td>1728.080±1825.054</td>
<td>1542.140±845.199</td>
<td>-10.760</td>
<td>0.503</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant.
4.5 Lipid profile of study participants pre-fasting and fasting

All parameters of the lipid profile; Cholesterol, high density lipoprotein, low density lipoprotein and triglycerides showed statistically significant increase during fasting with low density lipoprotein showing the highest increment of about 38% (Table 5).

**Table 5: Lipid profile of study participants.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD Pre-fasting</th>
<th>Mean ± SD Fasting</th>
<th>Percentage change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n= 200</td>
<td>n= 187</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>3.098 ± 0.446</td>
<td>4.253 ± 0.866</td>
<td>37.258</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>HDL (mmol/L)</td>
<td>1.307 ± 0.170</td>
<td>1.546 ± 0.204</td>
<td>18.318</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>LDL (mmol/L)</td>
<td>1.622 ± 0.411</td>
<td>2.295 ± 0.862</td>
<td>38.105</td>
<td>0.001*</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>0.592 ± 0.121</td>
<td>0.791 ± 0.231</td>
<td>33.688</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant

TC = total cholesterol
HDL = high density lipoprotein
LDL = low density lipoprotein
TG = triglycerides
4.6 Comparison among gender

There was a recorded decrease in all anthropometric measurements except percentage muscle mass which recorded an increase in both males and females. However systolic blood pressure recorded an increase in males only. The changes in anthropometric measurements were however not statistically significant in either gender (Table 6).

There was no statistically significant change in most hematological indices in both males and females. However, Basophils, eosinophil, MCHC and MCV showed statistically significant differences (Table 7).

Statistically significant decrease was observed during fasting for dietary intake of carbohydrate and protein with an increased fat intake in both males and female. However, total caloric intake decreased in males with an increased total caloric intake in females (Table 8).

Cholesterol, high density lipoprotein, low density lipoprotein and triglycerides in both males and females increased following fasting with statistically significant increase (Table 9).
Table 6: Comparison among male and female anthropometric measurements

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
<th>Mean ± SD</th>
<th>Percentage</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Fasting</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.021±19.842</td>
<td>67.576±15.618</td>
<td>-3.618</td>
<td>0.647</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.450±5.135</td>
<td>22.954±4.338</td>
<td>-6.516</td>
<td>0.532</td>
</tr>
<tr>
<td>BFAT (%)</td>
<td>26.050±9.311</td>
<td>22.538±10.960</td>
<td>-15.585</td>
<td>0.427</td>
</tr>
<tr>
<td>MMASS (%)</td>
<td>32.556±5.684</td>
<td>35.763±4.106</td>
<td>8.966</td>
<td>0.140</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>127.947±13.260</td>
<td>130.577±30.912</td>
<td>2.0138</td>
<td>0.850</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.256±16.780</td>
<td>68.683±20.025</td>
<td>-2.239</td>
<td>0.893</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.725±7.138</td>
<td>27.120±7.299</td>
<td>-2.182</td>
<td>0.686</td>
</tr>
<tr>
<td>BFAT (%)</td>
<td>39.008±9.792</td>
<td>37.868±10.646</td>
<td>-2.923</td>
<td>0.716</td>
</tr>
<tr>
<td>MMASS (%)</td>
<td>24.353±4.340</td>
<td>25.704±4.438</td>
<td>5.547</td>
<td>0.628</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>133.625±27.062</td>
<td>132.560±26.387</td>
<td>-0.797</td>
<td>0.987</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant.
Table 7: Comparison among male and female hematological indices.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD Baseline</th>
<th>Mean ± SD Fasting</th>
<th>Percentage Change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WBC ((10^9/L))</td>
<td>4.006 ± 1.427</td>
<td>4.115 ± 1.831</td>
<td>2.698</td>
<td>0.052</td>
</tr>
<tr>
<td>RBC ((10^{12}/L))</td>
<td>5.047 ± 0.534</td>
<td>4.796 ± 0.584</td>
<td>-4.973</td>
<td>0.381</td>
</tr>
<tr>
<td>HGB (g/dL)</td>
<td>13.635±1.454</td>
<td>20.123±30.427</td>
<td>47.593</td>
<td>0.705</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>44.990±4.338</td>
<td>42.877±8.484</td>
<td>-4.697</td>
<td>0.740</td>
</tr>
<tr>
<td>MCV (fl)</td>
<td>86.235±17.535</td>
<td>93.247±10.109</td>
<td>8.132</td>
<td>0.035</td>
</tr>
<tr>
<td>MCHC (g/dL)</td>
<td>30.297±0.954</td>
<td>28.741±2.138</td>
<td>-5.134</td>
<td>0.039*</td>
</tr>
<tr>
<td>PLT ((10^9/L))</td>
<td>227.483±65.139</td>
<td>226.235±62.663</td>
<td>-0.548</td>
<td>0.001*</td>
</tr>
<tr>
<td>LYMPPH((10^9/L))</td>
<td>1.912±1.010</td>
<td>2.393±1.261</td>
<td>25.145</td>
<td>0.049*</td>
</tr>
<tr>
<td>MONO ((10^9/L))</td>
<td>0.249 ± 0.170</td>
<td>0.179 ± 0.275</td>
<td>-28.279</td>
<td>0.065</td>
</tr>
<tr>
<td>EO ((10^9/L))</td>
<td>0.162 ± 0.153</td>
<td>0.059± 0.116</td>
<td>-63.636</td>
<td>0.003*</td>
</tr>
<tr>
<td>BASO ((10^9/L))</td>
<td>0.106± 0.152</td>
<td>0.003± 0.005</td>
<td>-97.262</td>
<td>0.001*</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WBC ((10^9/L))</td>
<td>4.701 ± 1.917</td>
<td>3.780±1.973</td>
<td>-19.583</td>
<td>0.793</td>
</tr>
<tr>
<td>RBC ((10^{12}/L))</td>
<td>4.633 ± 0.581</td>
<td>4.431± 0.610</td>
<td>-4.366</td>
<td>0.430</td>
</tr>
<tr>
<td>HGB((g/dL))</td>
<td>12.087±1.422</td>
<td>11.717±1.513</td>
<td>-3.055</td>
<td>0.214</td>
</tr>
<tr>
<td>HCT(%)</td>
<td>40.525±3.881</td>
<td>42.465±5.234</td>
<td>4.788</td>
<td>0.035*</td>
</tr>
<tr>
<td>MCV ((fl))</td>
<td>86.529±14.264</td>
<td>96.462±9.309</td>
<td>11.480</td>
<td>0.004*</td>
</tr>
<tr>
<td>MCHC ((g/dL))</td>
<td>35.167±38.485</td>
<td>27.641±2.003</td>
<td>-21.401</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>PCT ((10^9/L))</td>
<td>0.305 ± 0.275</td>
<td>0.257 ±0.095</td>
<td>-15.660</td>
<td>0.589</td>
</tr>
<tr>
<td>LYMPPH((10^9/L))</td>
<td>3.393 ± 6.857</td>
<td>2.247± 1.045</td>
<td>-33.780</td>
<td>0.247</td>
</tr>
<tr>
<td>MONO ((10^9/L))</td>
<td>0.309 ± 0.538</td>
<td>0.189 ± 0.236</td>
<td>-38.678</td>
<td>0.170</td>
</tr>
<tr>
<td>EO ((10^9/L))</td>
<td>0.217 ± 0.555</td>
<td>0.040± 0.060</td>
<td>-81.446</td>
<td>0.007*</td>
</tr>
<tr>
<td>BASO ((10^9/L))</td>
<td>0.021± 0.017</td>
<td>0.005± 0.009</td>
<td>-75.000</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant.
Table 8: Comparison between male and female dietary analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD Baseline</th>
<th>Mean ± SD Fasting</th>
<th>Percentage change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>1356.493±593.537</td>
<td>1338.607±590.580</td>
<td>-1.319</td>
<td>0.048*</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>171.743±161.163</td>
<td>182.957±160.984</td>
<td>6.129</td>
<td>0.074</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>99.236±82.983</td>
<td>93.607±79.556</td>
<td>-5.672</td>
<td>0.033*</td>
</tr>
<tr>
<td>total calories (g)</td>
<td>1628.036±717.133</td>
<td>1613.529±808.138</td>
<td>-0.899</td>
<td>0.016*</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>1226.126±592.306</td>
<td>1157.092±593.025</td>
<td>-5.966</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>148.800±149.286</td>
<td>212.096±422.271</td>
<td>42.538</td>
<td>0.006*</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>72.944±51.636</td>
<td>71.863±48.650</td>
<td>-1.482</td>
<td>0.015*</td>
</tr>
<tr>
<td>total calories (g)</td>
<td>1417.967±702.718</td>
<td>1547.459±912.561</td>
<td>9.132</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant.
Table 9: Comparison among male and female lipid profile

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
<th>Mean ± SD</th>
<th>Percentage</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Fasting</td>
<td>change</td>
<td></td>
</tr>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>3.135±0.348</td>
<td>4.450±0.955</td>
<td>41.946</td>
<td>0.002*</td>
</tr>
<tr>
<td>HDL (mmol/L)</td>
<td>1.278±0.103</td>
<td>1.478±0.134</td>
<td>15.656</td>
<td>0.002*</td>
</tr>
<tr>
<td>LDL (mmol/L)</td>
<td>1.735±0.462</td>
<td>2.512±0.984</td>
<td>44.767</td>
<td>0.041*</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>0.588±0.119</td>
<td>0.810±0.206</td>
<td>37.872</td>
<td>0.008*</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>3.077±0.503</td>
<td>4.135±0.810</td>
<td>34.390</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>HDL (mmol/L)</td>
<td>1.325±0.201</td>
<td>1.588±0.230</td>
<td>19.857</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>LDL (mmol/L)</td>
<td>1.555±0.373</td>
<td>2.16±0.777</td>
<td>39.305</td>
<td>0.006*</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>0.594±0.125</td>
<td>0.780±0.250</td>
<td>31.229</td>
<td>0.007*</td>
</tr>
</tbody>
</table>

Data is presented as mean ± standard deviation. P-value < 0.05 is statistically significant.
CHAPTER FIVE

5.0 DISCUSSION

5.1 Demographic characteristics of study participants

This study reports data on the effect of Ramadan fasting on hematological caloric intake, lipid profile and anthropometric parameters among Ghanaian Muslims. The study involved 200 Muslims undergoing a 30-day Ramadan fasting from the Sabon Zongo community in Accra. The majority of the study participants were females as against the males. This ratio agrees with the demographic data of Ghana which indicates that most Ghanaians from the age of 20 years and above comprise of more females than males (Ghana Statistical Service, 2005). Most of the participants had only primary education whereas a very few had tertiary education which is expected within a Ghanaian Zongo community.

5.2 Anthropometric measurements of study participants

This study recorded a decrease in body weight, percentage body fat and BMI following Ramadan fasting. Weight loss and decrease in BMI are predictable consequences of fasting although the decrease in weight and BMI were not statistically significant. A similar result was reported by Roky et al., (2004), Marbut et al., (2005) and Haouri-Oukerro et al., (2011). The decrease in weight and BMI seen in Ramadan fasting could be due to decreased frequency of food intake and also the quantity of food intake. A decrease in percentage body fat following Ramadan fasting was also recorded although there was an increased fatty food intake during the Ramadan fasting in this study. A similar observation was also reported by Hosseini et al., (2013). The decrease in percentage body fat could be due to the oxidation of body fat to provide energy. During fasting, there is the depletion of glucose stores due to starvation. The
body then resorts to the breakdown of fat deposits to produce free fatty acids. The body then oxidizes these free fatty acids to provide energy to the body to carry out its daily activities.

5.3 Dietary analysis of study participants

This study recorded a decrease in total calorie intake during Ramadan fasting although the decrease was not statistically significant. During Ramadan fasting, an individual is expected to have two meals per day which are Suhur, dawn meal and Iftar, meal after sunset. This does not mean that one should over-eat to make up for the other meals of the day. As part of the aims of Ramadan, one is expected to be in a state of moderation as described in Quran 7:32 that, one should eat and drink less and not in excess. Therefore, during the breaking of the fast, one is expected to quench the hunger and not to satisfy hunger. A “hadith” reported by Tirmidhi and Ibn Majab states that, one is expected to eat less and only one-third (1/3) of the stomach is expected to be filled with food. Bukhari and Muslim also reported in a hadith that, one is expected to eat just enough to keep him going and not to over-eat. This regulation in diet intake during the Ramadan fast could be an influence on the caloric intake of most fasting individuals. This could have accounted for the observed decrease in caloric intake. However, an increase in fat intake was recorded. It was observed during the study that, most of the participants had a lot of oily and fatty foods during the period of Iftar. A lot of fried foods were taken during the Ramadan period than the rest of the year. The observed increase in fatty food intake was also recorded in a study by Mansi, (2007) documenting that there is the tendency of increased intake of fatty foods during Ramadan fasting.

Increased fatty diet intake was probably necessary or good as the excess fat could be stored and used during the day as a source of energy for carrying out of one’s daily activities especially when the glucose stores are down.
5.4 Hematological analysis of study participants

There was an increase in some hematological indices (WBC, HGB, HCT, MCV and lymphocytes) and decrease in others (RBC, MCHC, monocytes, eosinophil and basophils) in this study. However, the changes were not statistically significant and within normal physiological limit. This agrees with work done by Abdulwahid, (2007) and AlHourani et al., (2009) where they reported that fasting which is a form of stress may have the ability to alter hematological indices. Increased hemoglobin level was observed with normal MCV and MCHC indicating that RBCs were not affected. This was also observed in the study by Abdulwahid, (2007). Although adrenal steroid levels were not measurement, stress has been predicted to increase adrenal steroid production (Dhabhar et al., 1996) which has the ability to decrease white blood cell levels especially eosinophil and basophils as seen in this study, although the changes were within normal physiological limits.

5.5 Lipid profile of study participants

Statistically significant increased serum lipid level was observed in this study. These elevations of TC, TG, LDL and HDL levels may be due to excess fat intake which was recorded in this study or lipolytic effect of starvation. The human body has regulatory mechanisms that are activated during fasting and the efficient utilization of fat. This mechanism helps in the breakdown of stored body fat so that it can be used as a source of energy in the absence of glucose. In the fasting state, glucose stores are depleted and this stimulates glucagon release to cause increase in lipolysis (breakdown of lipids). High fat diet has the tendency to improve blood cholesterol profile (Mansi, 2007). HDL has positive association with fat intake as it helps to get rid of excess cholesterol. High level of serum HDL has been found to lower the risk of heart diseases. Diets with high saturated fats produce high LDL. This was obvious in this study as
most of the participants had meals that had high concentrations of saturated fats. Contrary to this study, Haouari-Oukerro et al., (2011) recorded a decrease in serum lipid levels. Most studies reported a rise in tryglycerides with decrease in LDL, HDL and TC (AlHourani and Atoum, 2007; Mansi 2007; Saleh et al., 2005). Ismail and Haron, (2014) also recorded a decrease in TG levels. AlNahari and Kouja, (2014) also recorded increase in TG, TC and HDL with a decrease in LDL. This result strongly agrees with that of Pirsahed et al., (2013) and Adam et al., (2014) where they also recorded statistically significant increase in serum lipid levels for TC, TG, LDL and HDL.

It was observed also in this study that, hematological, anthropometric and serum lipid level parameters pre and post fasting were not different in both males and females. The only observed difference was seen in the dietary intake where females had significantly increased fatty food intake than males.
CHAPTER SIX

6.0 CONCLUSION

- It is concluded from this study that even though Ramadan fasting decreases weight, percentage body fat, BMI, hematological changes the effect is not significant. Whereas the percentage muscle mass, blood pressure, low density lipoprotein, high density lipoprotein, total cholesterol, triglycerides and fatty food intake are increase significantly during Ramadan fasting in Ghanaian Muslims.

- This study reports the first data on the effect of Ramadan fasting on hematological caloric intake, lipid profile and anthropometric parameters among Ghanaian Muslims.

6.1 RECOMMENDATIONS

1. This study could also be repeated in other religious fasting in Ghana such as the Christian fasting to compare the effects.

2. This study could also be repeated in other regions in Ghana so that result comparison could be made to help in trend drawing.

3. This study can be carried out in large groups of healthy and unhealthy individuals.

6.2 LIMITATION

This study could not be done in other regions in Ghana due to time and resources constrains.
REFERENCES


Ismail, W. I., & Haron, N. (2014). Effect of Ramadan Fasting on Serum Lipid Profile among Healthy Students in UiTM. In *International Conference on Biological, Chemical and Environmental Sciences* (pp. 51–53).


APPENDICES

APPENDIX I

INFORMED CONSENT FORM

PROJECT TITLE

The effect of Ramadan fasting on body anthropometric measurements, hematological indices and
serum lipid profile in Ghanaians.

NAME, POSITION, AND CONTACT INFORMATION OF RESEARCHER

Tawagidu Mohammed; MPHIL. Physiology, Department of Physiology, School of Biomedical
and Allied Health Sciences, College of Health science, University of Ghana, Korle-Bu, Accra,
Ghana.

Tel.0546740483.

SUPERVISOR

Principal supervisor: Dr. Rev. Charles Antwi-Boasiako; Department of Physiology, School of
Biomedical and Allied Health Sciences, University of Ghana, Korle-Bu, Accra, Ghana.

CO-SUPERVISOR

Dr. Bartholomew Dzudzor; Department of Biochemistry, School of Biomedical and Allied
Health Sciences, University of Ghana, Korle-Bu, Accra, Ghana.
I have been invited to take part in this research. I have been told the purpose of this research study is: To determine the effect of Ramadan fasting on some physiological parameters, oxidative stress and lipid peroxidation in Ghanaian Muslims.

I would be interviewed using an anonymous structured questionnaire to obtain information on socio-demographic and diet history. In addition I would be asked to provide blood sample (about 5 ml).

The risk or dangers and discomforts are:

By participating in this research, I am likely to have some discomforts. This includes the discomfort of questioning and the pain of blood collection. The investigator will try and decrease the chances of those risks/dangers happening, but if an untoward event happens, I will be provided with medical care which would be catered for by the investigator in the hospital.

Confidentiality:

The information that is collected from this research project will be kept confidential. Information about me that will be collected from the study will be stored in a file which will not have any name on it, but a number assigned to it. Which number belongs to which name will not be disclosed to anyone except the principal investigator. Results of this study will be compiled into a thesis and presented for the award of Master of Philosophy degree. Copies will be available at designated libraries for reference. Result will be presented at the Annual Scientific Conference, M.Phil. Seminar and also it will be published in local or International Journals.
My right to refuse or withdraw:

I do not have to take part in this research if I do not wish to do so. I may stop participating in this research at any time that I wish to.

Who may I contact?:

I have been told that this proposal has been reviewed and approved by the Ethical and protocol Review Committee, College of Health Sciences, University of Ghana. This is a committee whose job is to make sure that research participants are protected from harm.

Contact Information:

If I have any questions I may ask those now or later. If I wish to ask questions later, I may contact any of the following:

1. Tawagidu Mohammed, MPHIL. Physiology, Department of Physiology, School of Biomedical and Allied Health Sciences, College of Health science, University of Ghana, Korle-Bu, Accra, Ghana. Tel. 0546740483

2. Dr. Rev. Charles Antwi-Boasiako; Department of Physiology, School of Biomedical and Allied Health Sciences, University of Ghana, Korle-Bu, Accra, Ghana. Tel. 0244729026
APPENDIX II

QUESTIONNAIRE

To be completed by each subject participating in the study

Name: .............................................  Code: .............................................

Date: .............................................  Patient ID: .............................................

Tel: .............................................  E-mail: .............................................

Demographic and Anthropometric measurements

1. Age: .................................  6. Height: .................................
2. Weight (kg): ..........................  7. BMI (kg/m²): ..........................
3. BP: .................................  8. Pulse: .................................
4. % body fat: ...........................  9. Visceral fat: ...........................
5. % Muscle mass: ........................

Please tick [ ] the appropriate box where applicable

11. Sex  [ ] male
    [ ] female

12. Marital status  [ ] single  [ ] married
    [ ] divorced  [ ] widowed
13. Education  [ ] none  [ ] primary

[ ] secondary  [ ] tertiary

14. Occupation  [ ] unemployed  [ ] trader/self employed

[ ] government worker  [ ] others (please specify)………………

15. Ethnicity  [ ] Akan  [ ] Ga  [ ] Akwapim

[ ] Ewe  [ ] others (please specify)………………

16. How many times do you eat in a day?

[ ] two

[ ] three

[ ] four

[ ] five

17. What type of food do you mostly eat?

[ ] more carbohydrates and less meat and fish

[ ] less carbohydrates and more vegetables and fruits

[ ] less carbohydrates and more mat and fish
18. Do you smoke?

[ ] yes

[ ] no

If yes, [ ] 1 pack/day [ ] 2 pack/day [ ] >2 pack/day

19. How often do you have a drink containing alcohol?

[ ] never [ ] monthly or less

[ ] 2 or 4 times a month [ ] 2 to 3 times a week

[ ] 4 or more times a week

20. How many drinks containing alcohol do you have on a typical day when you are drinking?

[ ] 1 or 2 [ ] 3 or 4

[ ] 5 or 6 [ ] 7, 8 or 9

[ ] 10 or more

21. What type of alcoholic drinks do you take?

Specify…………………………..

22. How often during the last year have you found that you were able to stop drinking once you had started?

[ ] never [ ] than monthly

[ ] monthly [ ] weekly
23. Do you have any of the following conditions?

[ ] none          [ ] chronic liver disease          [ ] diabetes mellitus

[ ] chronic kidney disease          [ ] others (please specify)……………………
## APPENDIX III

### 24-HOUR QUESTIONNAIRE

<table>
<thead>
<tr>
<th>MEAL</th>
<th>TYPE OF FOOD</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LUNCH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BREAKFAST</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>