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Effects of Extended Fasting on Body Mass Index, Caloric Intake,
and Metabolic Rate among Saudi Students

By

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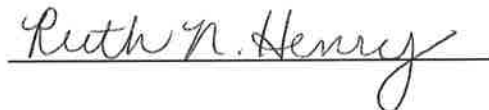
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Abstract

The month of Ramadan is the ninth month of the Islamic calendar where Muslims fast from dawn until dusk for 29 or 30 days. During the month of Ramadan Muslims around the world abstain from eating and drinking during day's hours except those who are bedridden or journeying and women who are bleeding due to menstruation or childbirth. The effects of fasting Ramadan on body mass index, caloric intake, and resting metabolic rate are heterogeneous. The differences in previous studies' findings are due in part to differences of the total amount of daily fasting time and the average number of fasting days. Therefore, the purpose of the study was to define the effects of fasting Ramadan on body mass index, daily caloric intake, and metabolic rate among Saudi students at Middle Tennessee University. At the end of Ramadan, Saudi students lost 1.15 kg, while there was no change in resting metabolic rate. Moreover, the daily caloric intake for Saudi students during the month of Ramadan was lower compared to regular months.

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Introduction

Muslims around the world fast from dawn to sunset during the holy month of Ramadan, which lasts between 29 and 30 days. Scientists have published many studies that investigate the impact of skipping meals on body weight, caloric intake, and resting metabolic rate. Surprisingly, fasting during Ramadan does not necessarily correlate with reduced body weight, caloric intake, and resting metabolic rate.

The effects of fasting on body weight and caloric intake are controversial. However, the specific effects of Ramadan fasting on metabolic rate are poorly characterized. A study conducted in London claimed that the average weight loss was one kilogram over 4 weeks (Hajek, Myers, Dhanji, West & McRobbie, 2012). On the other hand, a study that was conducted in Saudi Arabia showed weight gain during Ramadan. Most participants believe that the increase in body weight during Ramadan was due to the decrease of physical activity and the increase in food consumption (Bakhotmah, 2011). This difference can likely be attributed to variable fasting times and eating habits (Trepanowski & Bloomer, 2010). A study conducted in Algeria stated Ramadan fasting is associated with a reduction in caloric intake. However, this study examined only Type 2 diabetic obese women and did not address metabolic rate (Khaled & Belbraouet, 2009). In non-obese participants alternate-day fasting was associated with a reduced metabolic rate, but caloric intake was not addressed (Heilbronn, Smith, Martin, Anton & Ravussin, 2005).

The combined effects of fasting on Body Mass Index, caloric intake, and metabolic rate remain an open question among Muslims who fast during the month of Ramadan in the United States. Therefore, the purpose of the study is to examine these parameters in a sample of Saudi students who are fasting during the month of Ramadan in the state of Tennessee.

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Research Hypotheses

H₁: There are changes in Body Mass Index (BMI) among Saudi students after fasting the month of Ramadan in the state of Tennessee.

H₂: There are changes in resting metabolic rate (RMR) among Saudi students at the end of fasting the month of Ramadan in the state of Tennessee.

H₃: There are changes in daily caloric intake during Ramadan among Saudi students who are fasting the month of Ramadan in the state of Tennessee.

Key Words

Ramadan: The holy month in the Islamic calendar, where Muslims abstain from eating food or drinking liquids from dawn to sunset.

BMI: An abbreviation for Body Mass Index, which is an index used to measure body shape based on a person's weight and height.

RMR: An abbreviation for resting metabolic rate, which refers to the amount of daily energy expended by the body at rest.

Iftar: The evening meal where Muslims break the fast during Ramadan and happens at sunset.

Suhoor: The last meal before fasting; usually eaten between midnight and dawn during the month of Ramadan.

ELS: An abbreviation for English Language School (English as a Second Language Center).

Binge eating: Uncontrollable eating, where a person consumes an excessive amount of food.

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Limitations

There are three limitations to the study that include: age, education level, and gender. Most Saudi people living in the United States are students who are between 18 and 40 years old which makes it difficult to include people over 40 or younger than 18 years of age the study. Moreover, the majority of Saudi students living in the United States are sponsored by the Saudi government to study abroad for either higher education or certain bachelor majors, which makes it impossible for the principal investigator to reach Saudi people with lower education levels. The last limitation of the study is gender. Most Saudi students who agreed to participate in the study were male. However, to avoid some of the limitations, the principal investigator titled the study and made the thesis statements to be among Saudi students who attend Middle Tennessee State University.

Literature Review

The Month of Ramadan

Muslims accept five basic pillars of Islam. The first pillar, "*Shahadah*," refers to believing in one God and believing that the prophet Mohammed is the last messenger of God. The second pillar is prayer (*Salat*), where Muslims pray five times a day. The third pillar is the alms tax (*Zakat*), where Muslims donate 2.5% of their total earnings and savings once a year. The fourth pillar is fasting for the holy month of Ramadan (swam Ramadan). The last pillar is the pilgrimage to Mecca (*Hajj*); Muslims are obligated to conduct Hajj once in a lifetime for those who are physically and financially able to perform Hajj (Ali, Liu & Humedian, 2004). These five pillars encompass the common practices among Muslims worldwide.

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Of these five pillars of common practice, Ramadan is the only pillar that is directly connected to nutrition status. Muslims believe that there are many reasons to fast during the month of Ramadan, one of which is to train Muslims on controlling their desires through the month of Ramadan and the following months. Moreover, many Muslims believe that the main purpose of fasting during Ramadan is to increase empathy for those who are poor and hungry.

The month of Ramadan is the ninth month of the Islamic calendar (lunar calendar). During this month, adult Muslims fast (from both eating and drinking) every day from dawn until dusk, as well as abstain from engaging in sexual activities (Mafauzy, Mohammed, Anum, Zulkifli & Ruhani, 1990). However, Muslims who are bedridden or traveling have the option to refrain from fasting based on their physical ability to handle fasting. Moreover, women who are bleeding due to menstruation or childbirth are not allowed to fast. According to the Islamic Society of North America, the month of Ramadan began July 10, and lasted 29 days for the year 2013. According to the Islamic finder website, the average daily fasting time in the state of Tennessee was 15 hours and 29 minutes (Islamicfinder.org, 2013).

At the end of Ramadan, Muslims celebrate Eid Al-Fitr, a festival of Fast-Breaking, which lasts for three days. People dress in their best clothes, and the day begins with the Eid Al-Fitr prayer, followed by a feast of delicious food, meant to be eaten in the morning for the first time after a month of fasting. Communities, such as the Saudis and Indo-Pak, traditionally give their children "Eidi," which are money gifts similar to Hanukkah money in Jewish communities. In Turkey, children go door-to-door collecting candy (Gilani-Williams, 2007). "In the United States, Eid al-Fitr speaks to the truth that communities of faith—including Muslim Americans—enrich our national life, strengthen our democracy, and uphold our freedoms, including the

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freedom of religion” (Obama, 2012). In 2013, Eid al-Fitr took place on Thursday, August 8 (Islamicfinder.org, 2013).

Meal Frequency During Ramadan

The frequency of meals during the month of Ramadan is usually lower than meals during regular months. In a study conducted in Saudi Arabia published by *The Sleep and Hypnosis Journal*, BaHamman (2003) aimed to assess the effects of Ramadan fasting on eating habits. He reported a drop in meal frequency during the month of Ramadan. The average number of meals per day during the month before Ramadan was 2.7, while the average number of meals per day during the third week of Ramadan was 2 meals (BaHamman, 2003). Other researchers conducted a study in the United Arab Emirates and reported a similar reduction in meal frequency during Ramadan. The average daily meal frequency during the month before Ramadan was 3.2, while the average daily meal frequency during Ramadan was 2.1 (Sadiya, Ahmed, Siddieg, Babas & Carlsson, 2010).

During Ramadan, Muslims break the fast after sunset with their main meal, *Iftar*, or breakfast. Muslims usually follow the prophet Mohammed’s tradition in breaking the fast. Anas reported: “The Messenger of Allah would break his fast with ripe dates before he would pray. If those were not available, he would eat dried dates. If those were not available, he would drink some water” (Abram, 2011). During *Iftar*, Muslims usually gather for a feast, and the meal consists of a variety of food based on Muslim culture. In a study conducted in the United Arab Emirates published by *The Gulf News Journal*, Trepanowski and Bloomer reported that 70% of UEA citizens consume *Iftar* with family members. Saudis usually serve sweet and fried food during *Iftar* (Trepanowski & Bloomer, 2010). *Suhoor* is another important meal during the month of Ramadan and is the last meal before the day of fasting. It is eaten between midnight

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and dawn. Since *Suhoor* is the last meal before the day of fasting, many Muslims treat this meal as dinner and serve choices such as chicken, lamb, rice, and pasta (Trepanowski & Bloomer, 2010).

Lifestyle Changes During Ramadan

Many Muslims change their lifestyle to adopt the changes during Ramadan, including changes to sleeping patterns. Changes in sleeping patterns may alter the person's body mass index, caloric intake, and metabolic rate. BaHamman (2004) conducted a study in Saudi Arabia published by *Sleep and Biological Rhythms* aimed to determine the effect of Ramadan fasting on sleeping architecture and daytime sleepiness. He reported a reduction of 1 hour and 36 minutes in total sleeping time per day during the third week of Ramadan. However, the study did not indicate an increase in daytime sleep but did show a significant increase in the percentage of body fat directly linked to the lack of sleeping (BaHamman, 2004). The same researcher conducted a study on young healthy students published by *The Sleep and Hypnosis Journal*, aiming to assess the effects of fasting on total sleep time, sleep habits, and daytime sleepiness. The researcher reported a significant delay in bedtime during Ramadan compared with the previous month. In addition, the researcher reported an increase in participants who went to bed between 2 AM and 4 AM from 18% before Ramadan to 54% during the first 2 weeks of Ramadan. Also, the researcher reported a significant increase in participants who went to bed after 4 AM during the third week of Ramadan compared with the first week. Moreover, the researcher reported that only 10% of the participants mentioned that they get enough sleep during Ramadan's nights. BaHamman (2003) also reported a significant increase in participants who napped during Ramadan from 52% at baseline to 73% during Ramadan.

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Work schedules also change during Ramadan in Islamic countries. People try to avoid exposure to heat and reduce the energy expenditure while fasting. The average temperature in July and August is 45 degrees Celsius in most regions. Government offices, factories, and malls are closed during the day hours and open late during the nights of Ramadan. However, Saudi students in the United States cannot change class time. Accordingly, they must treat Ramadan as a regular month. Another lifestyle change during Ramadan in Muslim countries is a general reduction in physical activity during daytime hours. Waterhouse, Alkib, and Reilly conducted a study which aimed to assess lifestyle changes during fasting in Ramadan, including physical activity, between Muslims in Libya versus Muslims in the United Kingdom. They reported a significant reduction in physical activity during the daytime and a remarkable increase in physical activity after sunset in Libya. However, there was no significant change in physical activity for those who fasted in the United Kingdom (Waterhouse, Alkib & Reilly, 2008).

The Effects of Fasting on Physical Performance

During the month of Ramadan, Muslims usually postpone sport activities and exercise training until they break the fast. This rescheduling in exercise sessions may alter the trainer's performance during the month of Ramadan (Fallah, 2010). Karli, Guvenc, Aslan, Hazir, and Acikada completed a study, which aimed to define the effects of fasting Ramadan on anaerobic power and capacity and the removal rate of lactate after short time high intensity exercise in athletes. They reported no changes in the participants' caloric intake, sleeping time, or fluid intake during Ramadan. Moreover, the researchers reported no significant changes in anaerobic power and capacity and the removal rate of lactate. However, the authors believe that the changes on anaerobic power and capacity and the removal rate of lactate during Ramadan result

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from the changes in trainers' caloric intake, sleeping time, or fluid intake (Karli, Guvenc, Aslan, Hazir & Acikada, 2007).

Another group of researchers conducted a study on professional Algerian sports teams and aimed to define the effects of Ramadan on Muslim athletes. The researchers reported a significant reduction in speed, agility, and endurance. The average heart rate before the month of Ramadan after a 12 minute run was 134 beats per minute (bpm), while the average heart rate at the end of Ramadan after running the same distance was 165 bpm. Additionally, more than 65% of the participants believed that their performance was influenced during Ramadan. The reduction in the participants' performance might be related to the lack of sleep since 61% of the participants responded that their sleep quality was slightly worse during Ramadan compared to regular months (Zerguini, Kirkendall, Junge & Dvorak, 2007).

The Effects of Fasting on Lipid Profile

Fasting for a long period has an effect on human health. Many scientists have examined the effect of Ramadan fasting on different parameters. One of these parameters is lipid profile. The results of the studies have differed depending on where the study was conducted. Researchers who conducted a study in Algeria reported a significant increase in total cholesterol (7.82 vs 5.18 mmol/L) and a significant increase in LDL level (Khaled & Belbraouet, 2009). Another group conducted a study in Bristol, England published by *The American Journal of Clinical Nutrition* to determine the physiological changes during Ramadan. The results indicated an increase in serum cholesterol during the month of Ramadan (Fedail, Murphy, Salih, Bolton & Harvey, 1982).

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Adlouni, Ghalim, Benslimane, Lecerf, and Saile (1997) conducted a study in Morocco published by *Annals of Nutrition and Metabolism* to investigate the changes on serum cholesterol and triglycerides during Ramadan. The researchers reported a 7.9% decrease in serum cholesterol during Ramadan compared with the previous month. Moreover, the researchers reported a significant reduction in triglyceride concentrations. They also reported that the participants maintained the decrease in cholesterol and triglyceride levels for a month (Adlouni, Ghalim, Benslimane, Lecerf & Saile, 1997). Salehi and Negahb conducted a study in Pakistan published by *The Pakistan Journal of Biological Science* to assess the effects of Ramadan on blood indices in overweight males. They reported a significant reduction in total cholesterol levels with no change in triglyceride levels. However, the participants were asked to follow a balanced diet during Ramadan, which might have affected results of the study (Salehi & Negahb, 2007).

The Effects of Fasting on Body Weight

Fasting can also affect body mass index. Over the last few decades, many scientists have assessed the effects of Ramadan fasting on body weight. However, most of the scientists focused on specific groups such as students, families, and diabetic patients. Some of the scientists reported weight reduction during Ramadan, while others reported no change in weight or an actual weight increase.

Heilbronn, Smith, Martin, Anton, and Ravussin conducted a study published by *The American Journal of Clinical Nutrition* in 2005, aiming to define whether alternate-day fasting is a workable method for dietary restriction in non-obese participants. The researchers reported weight loss (2.5 \pm 0.5% of the initial body weight) and fat mass loss (4 \pm 1% of the initial fat mass) as a result of the dietary change. The study sample comprised 16 participants of both

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genders. However, the researchers targeted only non-obese participants, which raises the question of whether the result would apply for obese participants. The method used to measure weight was consistent; participants were asked to wear a hospital gown and weighed early in the morning (Heilbronn, Smith, Martin, Anton & Ravussin, 2005).

Other researchers conducted a study in Kuwait published by *Middle East Journal of Family Medicine*, aiming to assess the effects of Ramadan fasting on waist circumference and lipid profile. The researchers reported a significant reduction in the waist circumference (more than 2 cm in both genders) and a significant reduction in total cholesterol. However, the researchers did not address the effect of fasting on weight, and 68% of the participants were male (Almutairi, Alhendi, Alhelal & Mouro, 2012).

An Algerian study published by *The International Journal of Diabetes in Developing Countries* aimed to determine the effects of Ramadan fasting on body weight and food consumption in Type 2 diabetic obese women. The researchers reported a significant weight reduction during Ramadan (3.12 kg lost; 3.7% of body weight). However, the participants regained about 2.45 kg of the weight lost by one month later. In addition, the researchers reported a significant increase in fat consumption from 25% of total calories during the month before Ramadan to 36% of total calories during Ramadan. The authors used an electronic device to measure weight, and participants weighed early in the morning while they were wearing light clothes (Khaled & Belbraouet, 2009).

Another group conducted a study in London published by *The Journal of Public Health* to determine the effects of skipping meals on body weight during Ramadan. They reported one kilogram as an average weight loss during Ramadan. However, most participants returned to their initial weights one month after Ramadan. The average fasting time during this study was 15

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hours and 49 minutes per day, and most of the participants were natives of India (Hajek et al., 2012). Other researchers conducted a study in Tehran published by *The Singapore Medical Journal* to determine the changes of metabolic profile and weight during Ramadan. The researchers reported a significant decrease in BMI from 23.2 kg/m² during the month before Ramadan to 22 kg/m² immediately following the month of Ramadan for males. However, for females, the average change of BMI was only 0.4 kg/m² (Ziaee et al., 2006).

Maislos, Khamaysi, Assali, Abou-Rabiah, Zvili, and Shany (1993) conducted a study in Israel published by *The American Journal of Clinical Nutrition* aiming to define the effects of Ramadan fasting on plasma lipids in normal participants. These researchers addressed the effects of fasting concerning body weight. They reported no significant changes in body weight during Ramadan. The average weight during the month after Ramadan was 68.2 kg, while the average weight during the month of Ramadan was 68 kg (Maislos et al., 1993). Ali, Liu, and Humedian (2004) conducted a study on Tunisian females published by *The American Journal of Clinical Nutrition* to define the effects of fasting during Ramadan on metabolic parameters. They reported no changes in body mass index during the month of Ramadan compared with the previous month (Ali, Liu & Humedian, 2004).

Bakhotmah (2011) published a cross-sectional study using a questionnaire in *The Nutrition Journal*. It was conducted by the Department of Nutrition and Food Sciences, King Abdulaziz University, Jeddah, Saudi Arabia. The results indicated weight gain after Ramadan. In the study, 173 Saudi families were interviewed, and (59.5%) reported weight gain after Ramadan. The authors found that 40% of the participants consume food high in fat and carbohydrates during the *Iftar* meal. While 31% of the participants suggested the weight gain was mainly because of the lack of physical activity during Ramadan, 14% indicated that the

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increase in weight was because of high-calorie consumption during Ramadan. However, the method used to collect weight was not consistent since the participants reported their own weights, and thus may have overestimated or underestimated their weight. Moreover, the participants of the study were only females, and they lived in the same city (Bakhotmah, 2011).

The Effects of Fasting on Daily Caloric Intake

Many scientists have determined the effects of fasting during Ramadan on daily caloric intake and food consumption. Khaled and Belbraouet (2009) conducted a study in Algeria published by *The International Journal of Diabetes in Developing Countries* to assess the effects of fasting during Ramadan on food consumption in Type 2 diabetic obese women. The researchers reported a significant decrease in daily caloric intake (-335 kcal/d, -18%) during the month of Ramadan compared with the previous month. They also reported the percentage of calories from each meal during Ramadan. Calories from *Iftar* represented 76% of the total caloric intake, while *Suhoor* represented only 14% of the total caloric intake. While they reported a reduction in carbohydrates and fiber intake, the researchers reported a significant increase in protein and fat intake during Ramadan. The results may differ for Muslims who do not have a good nutritional background (Khaled & Belbraouet, 2009).

Another group of researchers conducted a study on nine trained young males, aged 19 to 21, published by *Annals of Nutrition and Metabolism* to investigate the changes on body composition and growth hormones while fasting. The researchers compared the nutrient intake before and during Ramadan. In agreement with the previous study, the researchers of this study reported a significant increase in total fat intake and a significant decrease in carbohydrate intake while there was no significant change in protein intake. The researchers also reported a significant reduction in daily caloric intake during Ramadan (Bouhleb et al., 2008).

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Many Muslim families train children at young ages on fasting during Ramadan. Poh, Zawiah, Ismail, and Henry (1996) conducted a study in Malaysia published by *The Malaysian Journal of Nutrition* aimed to assess the effects of fasting on school children between the ages of 10 and 13. They reported a reduction in daily caloric intake on both genders during Ramadan. The average daily caloric intake reduction for boys was 290 Kcal, and the average reduction in daily caloric intake for girls was 310 Kcal. These researchers also reported a significant reduction in fat and carbohydrate intake for both genders, but no significant changes in protein intake during Ramadan. Their results indicated that most participants met the recommended nutrient intake, except for protein, which was lower than the value recommended in most participants (Poh, Zawiah, Ismail & Henry, 1996).

Al-Hournai and Atuom (2007) conducted a study in Jordan published by *The Singapore Medical Journal* to assess the effects of Ramadan on body composition. They studied 57 healthy female college students with a mean age of 21 years using 3-day food records (two during weekdays and one during the weekend) to assess the daily caloric intake. They reported a significant reduction in meal frequency, but no significant difference in caloric intake between Ramadan and the previous month. The average caloric intake before the month of Ramadan was 1252 Kcal/d, while the average caloric intake during the month of Ramadan was 1171 Kcal/d. Moreover, there were no significant differences in fat, protein, and carbohydrate consumption during Ramadan compared with the previous month (Al-Hournai & Atuom, 2007).

Another group conducted a study in the UAE published by *The Diabetes, Metabolic Syndrome and Obesity Journal* to assess the effects of fasting on native Emirates with metabolic syndromes. The researchers also used 3-day food records to assess the caloric and nutrient intakes and reported a significant decrease in meal frequency and protein intake. They reported a

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significant increase in fat consumption (23% increases in fat intake compared with the month before Ramadan). In addition, the researchers reported no significant change in daily caloric intake during Ramadan compared with the previous month. Most of the participants in this study were female, and because females are not allowed to fast during their menstrual cycle, the results may have been skewed (Sadiya et al., 2011).

Kassab, Abdul-Ghaffar, Nagalla, Sachdeva, and Nayar (2003) conducted a study on Bahraini females published by *The Asia Pacific Journal of Clinical Nutrition* aiming to assess the effects of fasting during Ramadan on leptin and insulin levels and also assessed the daily caloric intake during Ramadan. Surprisingly, the researchers reported a significant increase in daily energy intake during the middle of Ramadan compared with the previous month in both lean and obese participants. The average increase in caloric intake for lean participants was 81 Kcal/day, while the average increase for obese participants was 102 Kcal/day. Study results indicate that the positive daily caloric intake during Ramadan was due to the increase in food intake during Ramadan nights (Kassab, Abdul-Ghaffar, Nagalla, Sachdeva & Nayar, 2003).

The Effects of Fasting on Metabolic Rate

Many studies have been conducted to determine the correlation between hunger levels and metabolic rate. Researchers conducted a study published by *The American Journal of Clinical Nutrition* to define the correlation between hunger levels, daily caloric intake, and resting metabolic rate. The researchers reported a positive relationship between daily caloric intake and resting metabolic rate in overweight and obese participants. (The increase in RMR is related to increased food intake). Moreover, the researchers reported an increase in hunger levels for participants who had high-resting metabolic rate values (Caudwell et al., 2013). In addition,

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many studies on fasting have demonstrated changes in hunger feelings during fasting, raising concerns about the effects of fasting on the metabolic rate.

Another group conducted a study published by *The American Journal of Clinical Nutrition* in 2005 and reported an increase in hunger levels and a decrease in fullness levels during alternate-day fasting. However, the researchers reported no significant changes in metabolic rate and the participants did not fast every day (Heilbronn, Smith, Martin, Anton & Ravussin, 2005).

In the aforementioned study conducted by Ali, Liu, and Humedian (2004) on Tunisian females, resting energy expenditure (REE) did not change during Ramadan when compared with the previous month. However, the authors reported a decrease in energy expenditure during daytime fasting hours, while there was no significant difference in energy expenditure during the night time when compared with the preceding month. In addition, daytime fasting induced a significant decrease in respiratory quotient (RQ) (Ali et al, 1995).

The Effects of Fasting on Growth Hormone

During fasting periods, human bodies experience a series of metabolic and hormonal changes (Norrelund, Nair, Jorgensen, Christiansen, & Moller, 2001). One of these changes occurs to growth hormone (GH), which is produced by the pituitary gland. The changes in GH secretions can directly affect adiposity among obese people by controlling lipolysis (the breakdown of triglycerides into free fatty acids) and lipogenesis (fat accumulation) (Erman, Veilleux, Tchernofof & Goodyer, 2011). A group of researchers conducted a study published by the *Journal of Clinical Investigation* in which they reported a significant enhancement in GH secretion during fasting (Ho et al., 1988). However, the participants were asked to abstain only from eating and were allowed to drink water, which raises a concern regarding whether the

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study's results would apply to Ramadan fasting, where Muslims abstain from consuming both food and liquid. Another group conducted a study on healthy young males published by the *European Journal of Endocrinology* aiming to determine the reasons behind the enhancing of GH during fasting. They reported that the main driving force behind the enhancement of GH secretion during fasting is ghrelin, which is a hormone released by distinct endocrine cells in the stomach (Muller et al., 2002).

Conclusion

The effects of Ramadan fasting on body mass index, daily caloric intake, and metabolic rate are heterogeneous. The differences in previous studies' findings are due in part to differences of the total amount of daily fasting time and the average number of fasting days. Moreover, participants' food choices, food habits, and lifestyle had a strong influence on previous studies' findings (Trepanowski & Bloomer, 2013). However, none of the previous studies have addressed the effects of Ramadan on these parameters (BMI, Caloric intake, and MR) together. Therefore, the purpose of this study is to define the effects of fasting Ramadan on body mass index, daily caloric intake, and metabolic rate among Saudi students at Middle Tennessee State University.

Methods

Participants and Recruitment

Participants were selected by convenience sampling of Saudi Muslim students (18 years and older) at Middle Tennessee State University (MTSU). The director of the English as a Second Language School and the Saudi Students Organization at MTSU facilitated the study recruitment. The principal investigator explained the purpose of the study and the procedures to Saudi students during classes. Students who agreed to participate in the study signed the consent

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form on the recruitment day (see Appendix A). The study's initial population was $N = 40$, from various educational backgrounds. However, only 18 participants completed the study (male = 17, female = 1), due to scheduling conflicts and travel to Saudi Arabia for the Islamic holiday. Most participants were single and never married (88.9% of participants were single; 11.1% of participants were married). Their mean age was 25.44 years and the approximate average fasting days for the participants was 28 days.

Materials

The materials used in the study consisted of six food diary record sheets, portion size instruction sheets, the Food Processor software, a digital weight scale, a height indicator tape, a MedGem Indirect Calorimeter, and a survey of Ramadan.

The food diary record sheets addressed time, amount, and qualitative description of food (see Appendix B). On the recruitment day, the principal investigator provided oral and written instruction (in Arabic and English) to participants about portion size and food diary record (see Appendix C). Prior to the month of Ramadan, participants were asked to complete three daily food records (two during weekdays and one during the weekend) and return them on the first day of Ramadan. Food records were analyzed using the Food Processor software for Windows (version 10.12, ESHA Research Inc., 2013.)

The digital weight scale used in the study was manufactured by the Health-O-Meter company. This Health-O-Meter model measures up to 400 pounds in 0.2-pound increments and has a platform size of 15.2 inches \times 12.8 inches, but the actual display size is 3.0 inches \times 2.0 inches. The Health-O-Meter scale meets all the FDA requirements by means of BIA (bioelectrical impedance analysis). The Health-O-Meter scale was set to measure weight in kilograms.

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The MedGem Indirect Calorimeter is a handheld device used to determine RMR and VO_2 (MedGem; Microlife Medical Home Solutions, Inc., Golden, CO, USA). The MedGem Indirect Calorimeter provides oxygen consumption measurements and applies a simple calculation to provide RMR in Kcal per day (see Appendix D). It is very important that the participants be calm and relaxed while taking the test. For this reason, the principal investigator asked the participants to use their phones (to play music) while taking the test. The RMR test must be performed at least 4 hours after exercise and consumption of food or caffeine, and an hour after nicotine use.

The survey of Ramadan, reviewed and approved by the Institutional Review Board at Lipscomb University and MTSU (see Appendix E), consisted of eight questions: four multiple-choice questions and four Likert four-point-scale agree/disagree questions. The survey of Ramadan contained questions about age, gender, education level, marital status, physical activity, and dietary habits during Ramadan (see Appendix F) was used to obtain general information from the participants and assess physical activity level during the month of Ramadan.

Procedure

Testing occurred in a quiet conference room at the ELS center. Upon arrival on the first day of Ramadan, the participants turned in the food diary record sheets. The principal investigator reviewed the food diary records with each participant for accurate results. Then, the principal investigator asked the participants to empty their pockets and take off their shoes before weighing them. After weighing the participants, the principal investigator asked them to sit in comfortable chairs preparing them for the RMR test. The principal investigator performed the RMR test on each participant with a maximum time of 10 minutes (see Appendix H). Before the participants left the testing room, the principal investigator answered questions and distributed another 3-day food record sheet to be completed in the month of Ramadan.

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Upon arrival on the last day of Ramadan, the participants submitted the food diary record sheets and the principal investigator reviewed the food diary records with each participant. The measurements for weight and RMR were repeated on this last day of Ramadan. After taking their weights and RMRs, the principal investigator asked participants to report their heights. For those who did not know their heights, the principal investigator used a height indicator tape to measure their heights. Before the participants left the testing room, the principal investigator asked the participants to complete the survey of Ramadan and answered questions.

Data Analyses

Descriptive statistics in the form of mean values and standard deviations were calculated by the SPSS 21.0.0.0 for Windows Statistics Package (IBM SPSS, 2012). The relative significance of the differences between variables was determined via a paired, 2-tailed t test. The rejection level for all analyses was set at $\alpha = .05$. Descriptive statistics were also used for the survey response data.

Results

Total body weight of each of the participants (N=18) was measured and analyzed at the beginning and at the end of Ramadan. The mean measured body weight (BW) for the participants was initially 75.94 kg and decreased significantly to a mean of 74.80 kg at the end of Ramadan ($t=4.15$, $SD=1.15$ kg, $p=0.001$). The confidence level was set at 95%. The Body Mass Index (BMI) of each of the participants (N=18) was calculated and analyzed at the beginning and at the end of Ramadan. The mean calculated Body Mass Index (BMI) for the participants was initially 25.37 kg/m² and decreased significantly to a mean of 24.98 kg/m² at the end of Ramadan ($t=4.22$, $SD=0.39$ kg/m², $p=0.001$). The confidence level was set at 95%.

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The resting metabolic rate (RMR) of each of the participants (N=18) was measured and analyzed at the beginning and at the end of Ramadan. The mean measured resting metabolic rate (RMR) for the participants was initially 1518 Kcal/day and decreased slightly to a mean of 1496 Kcal/day at the end of Ramadan without statistically significant reduction ($t=0.377, SD= 244$ Kcal/day, $p=0.711$). The confidence level was set at 95%.

The oxygen consumption (VO_2) of each of the participants (N=18) was measured and analyzed at the beginning and at the end of Ramadan. The mean measured VO_2 for the participants was initially 219.4 ml/min and decreased slightly to a mean of 216.5 ml/min at the end of Ramadan without statistically significant reduction ($t=0.353, SD= 35.4$ ml/min, $p=0.729$). The confidence level was set at 95%.

The average daily caloric intake was measured and analyzed for each of the participants who completed a food record (N=10) the month before Ramadan and during the month of Ramadan. The mean measured average daily caloric intake for the participants at baseline was 1,631 Kcal/day and decreased significantly to a mean of 1,068 Kcal/day during the month of Ramadan ($t=3.79, SD= 470$ Kcal/day, $p=0.004$). The confidence level was set at 95%. The average daily meal frequency of each of the participants (N=10) was measured and analyzed the month before Ramadan and during the month of Ramadan. The mean measured meal frequency for the participants was initially 2.7 meals per day and decreased significantly to a mean of 1.95 meals per day during the month of Ramadan ($t=6.7, SD= .35, p<0.001$). The confidence level was set at 95%.

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The Survey Result Report

The SPSS Statistical Software Package was used to analyze the data obtained from the Survey of Ramadan. The survey was conducted to obtain additional information related to dieting and exercising during the month of Ramadan. The participants (N=18) completed the survey at the end of Ramadan.

For physical activity level, 55.6% of participants agreed to a statement that indicated a reduction in their physical activity level during the month of Ramadan, and 22.2% of participants strongly agreed with the same statement. For exercising during the month of Ramadan 44.4% of participants answered, “one to two times,” to the question, “How many times did you exercise per week during the month of Ramadan?”, while 38.9% of participants answered, “none,” to the same question (see Figure 1 & 2).

For binge eating during Iftar, 38.9% of participants disagreed with a statement that indicated binge eating was common during Iftar among people they know, while 55.6% of participants either agreed or strongly agreed with the same statement. For binge eating during Suhoor, 61.1% of participants either disagreed or strongly disagreed with a statement that indicated binge eating was common during Suhoor among people they know, while 22.2% of participants strongly agreed with the same statement (see Figure 3 & 4).

For sleeping patterns changes during Ramadan, 55.6% strongly agreed with a statement that said, “Your sleeping patterns changed during Ramadan”, and 33.3% of participants agreed to the same statement (see Figure 5).

Discussion

The purpose of this study was to examine the effect of fasting during the month of Ramadan on the body mass index (BMI), the resting metabolic rate (RMR), and the daily caloric intake among Saudi students in the U.S. state of Tennessee. The main findings of this study were a reduction in body weight (BW) and BMI at the end of Ramadan compared to the baseline (body weight reduction = 1.15 kg and, BMI reduction = 0.39 kg/m²). The reductions in BW and BMI were accompanied by a reduction in meal frequency and daily caloric intake during the month of Ramadan (meal frequency reduction = 0.75 meals and caloric intake reduction = 563 Kcal/day), while the resting metabolic rate was stable.

The reduction in the average body weight in this study is similar to that in a study conducted in London (Hajek et al., 2011). This similarity strengthens the assumption that Muslims in western countries who fast during Ramadan usually lose weight. However, the findings of this study might not apply to Muslims in Islamic countries who fast during Ramadan since they tend to change their lifestyle to adapt to the changes during Ramadan. Moreover, the findings of this study might not be similar to those found when Ramadan occurs during winter since the average fasting time in winter is lower than in summer due to shortened days (fewer daylight hours). Participants in this study lost weight during Ramadan as a result of a reduction in meal frequency and caloric intake while resting metabolic rate remained stable.

According to the survey in this study, most of the participants agreed to the statement that they decreased their activity level during Ramadan. If the participants maintained or increased their physical activity level during Ramadan, while reducing their daily caloric intake by more than 500kcal per day, their weight lost at the end of Ramadan was more than 1.15 kg. Further

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studies would be required to determine whether this weight loss during Ramadan is fat loss or muscle loss.

The average resting metabolic rate and the average oxygen consumption were slightly lower at the end of Ramadan, but neither decreased significantly. Most participants at the end of Ramadan arrived about an hour earlier than their scheduled times to measure their RMR and VO_2 , due to scheduling conflicts; most of them had to take exams during the last three days of Ramadan. Measuring their RMR at the same time of day at the beginning and at the end of Ramadan would have provided more accurate results. However, since fasting for Ramadan does not reduce the resting metabolic rate, Ramadan might be a good time to begin caloric restriction for people who want to lose weight.

According to the survey about Ramadan, binge eating seems to be a common habit during the *Iftar* meal. According to their daily food records, most participants treated *Iftar* as a feast and added meats such as chicken, beef, and lamb. On the other hand, most participants believed that binge eating was not a common habit during *Suhoor*. Again, according to their daily food records, most participants treated *Suhoor* as a light meal and they chose sandwiches and fruits. Moreover, some of the participants skipped the *Suhoor* meal for several nights and ate snacks before bedtime.

Most survey participants reported that they only exercised once or twice a week during Ramadan. Three possible reasons may explain why the participants did not exercise more during Ramadan. First is the difficulty of exercising during the day while they were fasting because the weather was hot and humid in Tennessee. The second possible reason is that the recreation center at MTSU closes early, and therefore, the participants were not allowed to use it during night

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hours. The third plausible reason is that the time between the *Iftar* meal and bedtime was not long enough for the participants to exercise.

Recommendations for Further Study

Based on the results of this and previous studies, Ramadan is a serious event that requires special nutrition intervention. People who might be at risk during Ramadan and who might need special nutrition care include:

1. *People with diabetes mellitus.* Since there was a reduction in meal frequency during Ramadan, diabetic patients need to monitor blood glucose carefully and eat complex carbohydrates during *Suhoor* to avoid hypoglycemia.
2. *Athletes and other physically active people.* Since there were reductions in the average body weight and caloric intake, the chances that athletes will lose lean mass are high. To avoid this loss, athletes need to track their caloric intake during Ramadan and make high-quality protein choices for *Iftar* and *Suhoor*.
3. *Pregnant women.* During pregnancy, women need extra calories and must make healthy food choices, especially during the second and the third trimesters when extra calories are needed for adequate growth of the fetus. Further studies might be required to assess the nutritional status of pregnant women who are fasting during Ramadan.

For this population of Saudi students living in the United States, Ramadan fasting induces weight loss via reduction in meal frequency and caloric intake. This weight loss did not appear to be harmful; however, there are groups who would be at risk of malnutrition during Ramadan. Thus, for healthy Saudi students, Ramadan might be a good time to begin a weight loss diet if Ramadan occurs during summer months when days are longer, and the weather is hot and humid.

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Table 1. Paired Sample Tests

Test name	M	SD	Std. Error Mean	95% Confidence Interval of the Difference		<i>t</i>	Sig. (2-tailed)
				Lower	Upper		
BW at the beginning & at the end	1.133	1.158	.273	.557	1.709	4.150	.001
BMI at the beginning & at the end	.388	.391	.092	.194	.583	4.220	.001
RMR at the beginning & at the end	21.666	224.088	57.532	-99.175	143.049	.377	.711
VO ₂ at the beginning & at the end	2.944	35.402	8.344	-14.660	20.549	.353	.729
Average caloric intake before and during Ramadan	563.20	470.040	148.63	226.953	899.446	3.789	.004
Meal frequency before and during Ramadan	.750	.353	.111	.497	1.002	6.708	.000

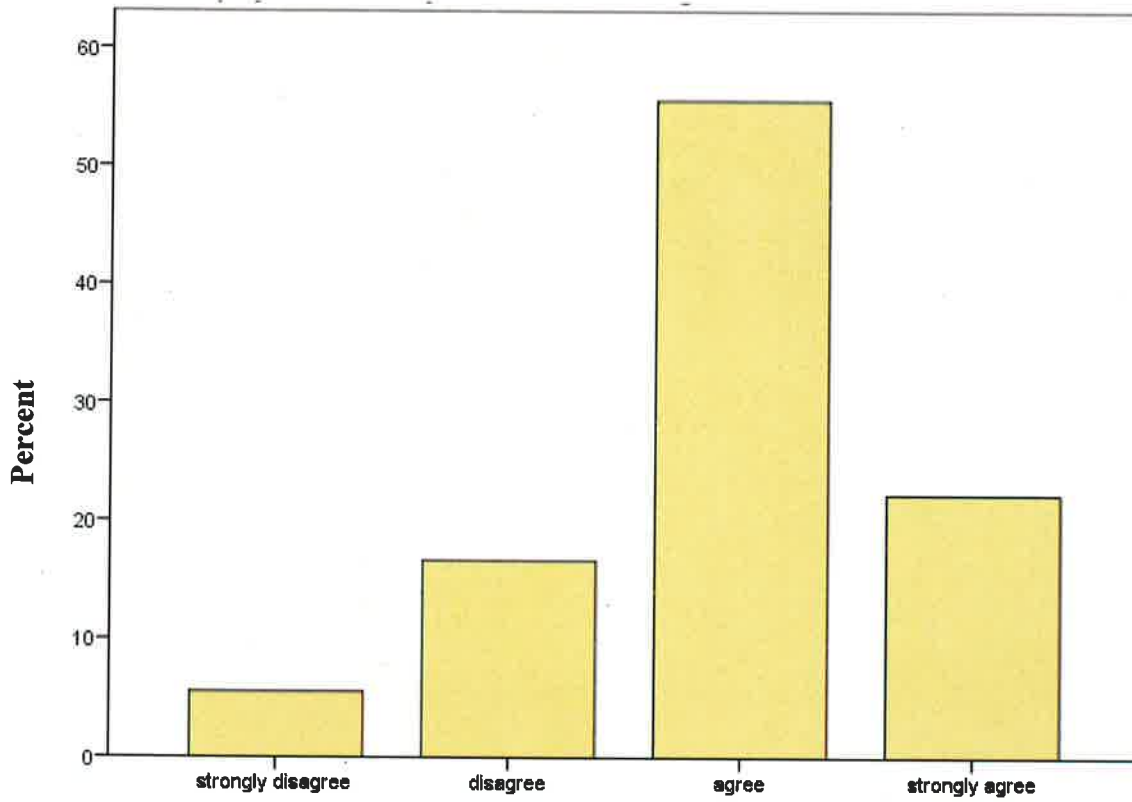


Figure 1. Your physical activity decreased during the month of Ramadan

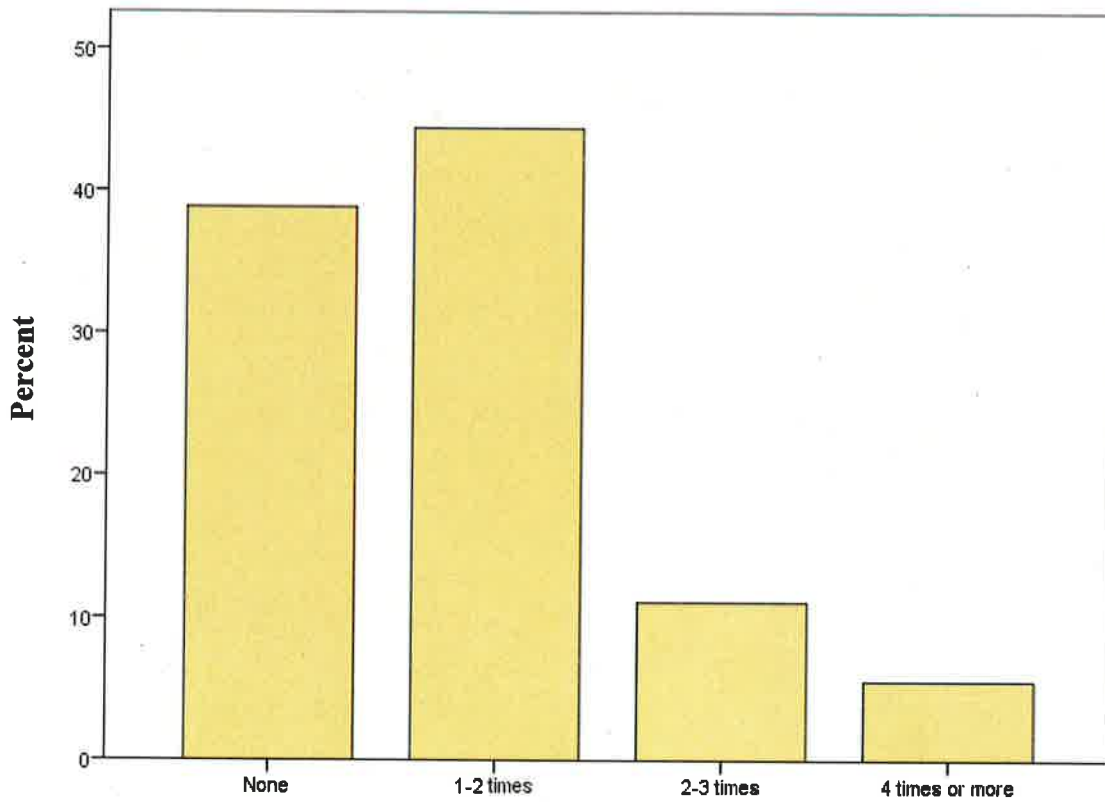


Figure 2. How many times did you exercise per week during Ramadan?

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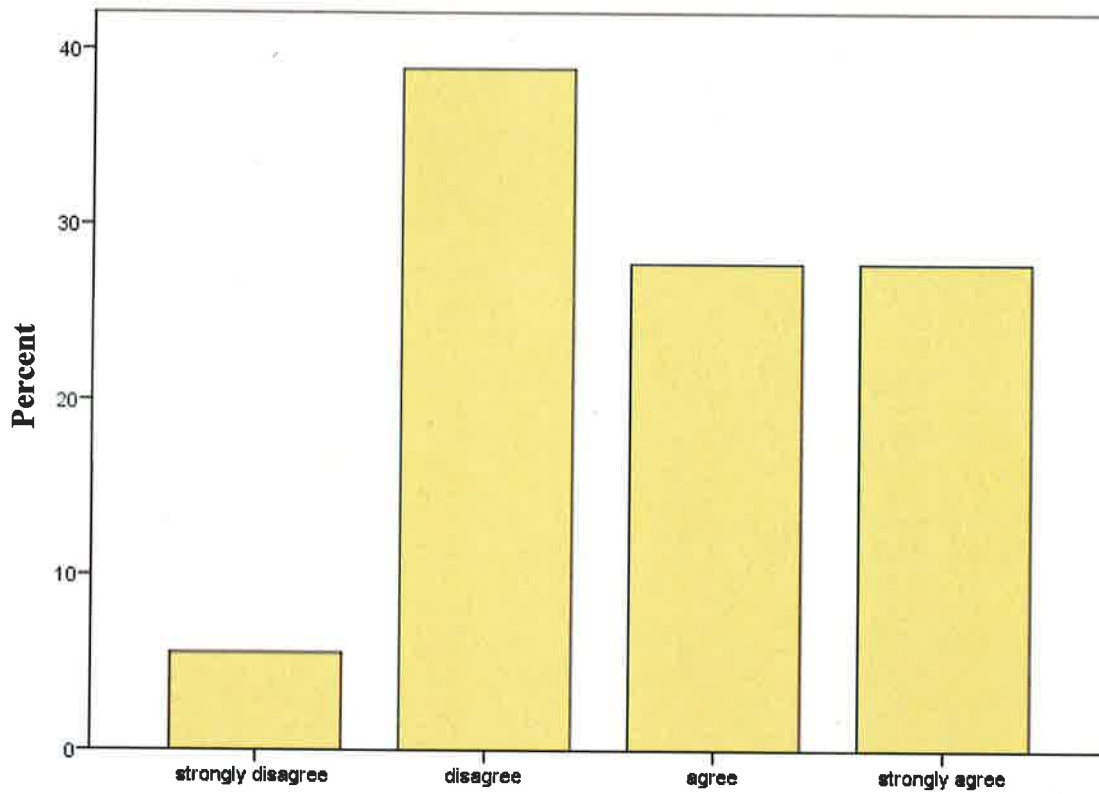


Figure 3. Binge eating was common during *Iftar* among people you know

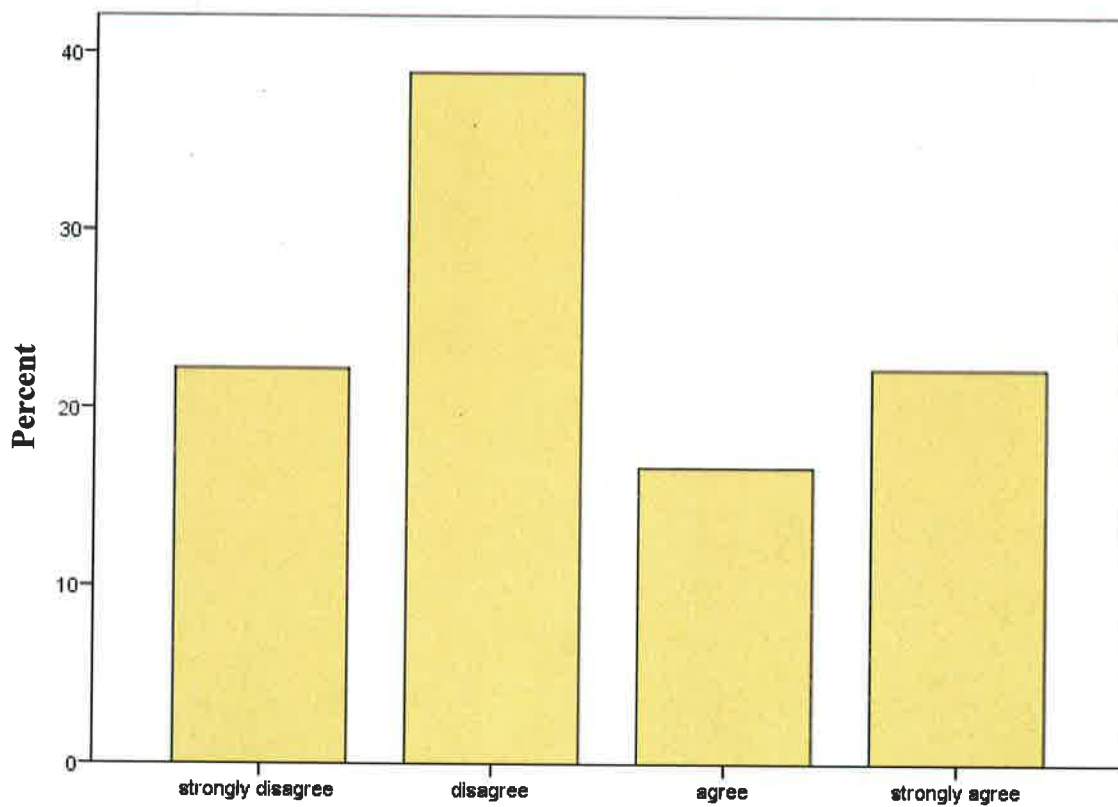


Figure 4. Binge eating was common during *Suhoor* among people you know

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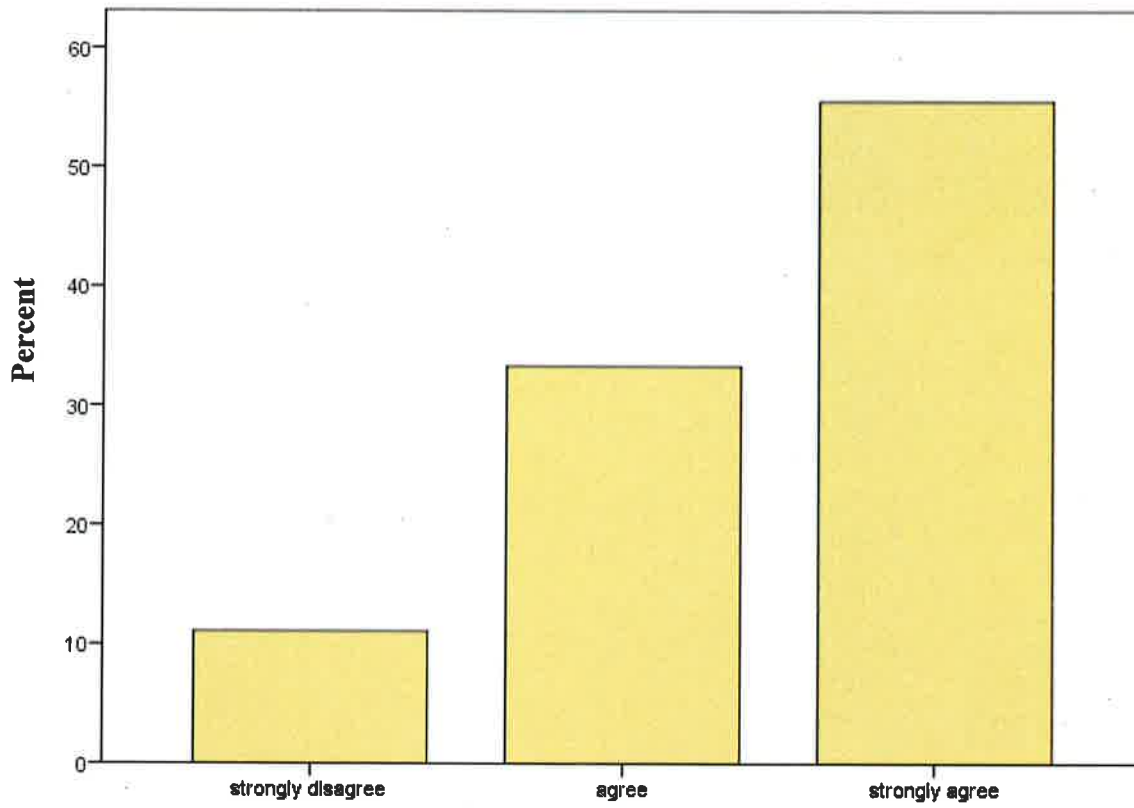


Figure 5. Your sleeping patterns changed during Ramadan

Appendix A

MTSU
IRB Approved
Date: 5/21/2013

Informed Consent Form

Please consider this information carefully before deciding whether to participate in this research.

Purpose of the research: To examine the effects of Ramadan fasting on Body Mass Index, caloric intake, and metabolic rate.

What you will do in this research: We will measure your height and weight, and you will complete a 3-day food diary (before and during Ramadan). At the end of Ramadan you will be asked to complete a survey that contains eight questions with approximate time of two to three minutes to finish the survey. The questions in the survey are about the dietary habits, physical activity, and sleeping patterns during Ramadan. Moreover, you will be asked to breathe into the mouthpiece of the Medgem Indirect Calorimeter. The calorimeter will measure the amount of oxygen you breathe in and the amount of carbon dioxide you breathe out over the course of several minutes (5 to 10 minutes total.) You will be given a clamp to hold your nose so that all of your breathing will be done through your mouth. The mouthpiece is small and is disposable; you will not share a mouthpiece with anyone else. The calorimeter will use the information gathered to calculate your resting energy expenditure.

Time required: Participation will take approximately 25 to 30 minutes to complete.

Cost: There is no cost to participants.

Risks: There are no anticipated risks associated with participating in this study. If you experience any psychological discomfort from completing the survey you are free to withdraw from the study any time. The calorimetry test will require you to breathe into a mouthpiece for several minutes. Typically there is no discomfort from this test, but you are welcome to withdraw at any time if you experience any discomfort either physically or psychologically from the test.

Alternative treatment: There is no alternative treatment available.

Compensation: There is no compensation for participation in the study. MTSU will not provide compensation in case of study-related injury. Lipscomb University will not provide compensation in case of study-related injury.

Benefits: At the end of the study, we will provide an explanation of the study and of our hypotheses. Moreover, we will provide you with your BMI, caloric intake, and metabolic rate (resting energy expenditure as calculated by the MedGem.)

Confidentiality: Your participation in this study will remain confidential, and your identity will not be stored with your data. Your responses will be assigned a code

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number, and the list connecting your name with this number will be kept in a locked room and will be destroyed once all the data have been collected and analyzed. All efforts, within reason, will be made to keep the personal information in your research record private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, Lipscomb University Institutional Review Board, and representatives of the Exercise and Nutrition Science Program at Lipscomb University, if you or someone else is in danger or if we are required to do so by law.

Participation and withdrawal: Your participation in this study is completely voluntary, and you may withdraw at any time without penalty. You may withdraw by informing the researcher that you no longer wish to participate (no questions will be asked). The principal investigator may withdraw you from study participation in the event you do not complete all the procedure.

How to contact the researchers: If you have questions or concerns about your participation, or want to request a summary of research findings, please contact the researcher: (Mohammed Alquraishi, mialquraishi@mail.lipscomb.edu, phone number 551-221-5276). For any other problems related to this study, you may also contact the faculty member supervising this work: (Dr. Autumn Marshall, autumn.marshall@lipscomb.edu).

Agreement: The nature and purpose of this research have been sufficiently explained and I agree to participate in this study. I understand that I am free to withdraw at any time without incurring any penalty.

Signature: _____ Date: _____

Name (print): _____ Date of birth _____

Appendix B

DAILY FOOD RECORD

Date: _____ Day of the week: _____

Please list all food/beverages/water. Measure all food/drink amounts accurately.

TIME	Amount	Description	Notes

Was this a typical day? If not why?

.....

DAILY FOOD RECORD INSTRUCTION

We are asking you to keep a daily food record so we can copy what you eat to track your daily calories intake. Here are instructions on how to complete the food record.

Time of eating is important to see how often you eat.

Amount: In this space, indicate the amount of the particular food item you ate. Measure or estimate the size, the volume, the weight, and/or the number of items of that type of food. For more information on estimating portion size when exact weight or measures are not available, the rules of thumbs may help, please check out this link

<http://goo.gl/IQmcn>

Description: In this space, write down the type of food you ate, and how the food was prepared (baked, broiled, grilled etc.). Moreover, if the food was homemade please add the recipe.

Notes: In this space, write down any adding to the food such as sugar, cream, mayonnaise, ketchup etc.

ماياً تثلثة دةملي مويلا يئاذغلا ريرقتلا تئبعت عمجلا نم عاجرلا
للاذ تثلثاوا عوبسلا للاذ نيموي (تقرعمل) عوبسلا تياهن تظع
ميرارحلا تارحسلا لكلاهتسا لدعم

يئلا يء يوتحي يئاذغلا ريرقتلا لودج

تقولا-Time:

ايموي كلهتسما تابجولا ددع باسح مهم لكلا تقولا ليجست

رادقما-Amount:

مذه يء كلهتسما ماعطلا تيمك تباتك عاجرلا مناخلا مذهب تحت
ومعضو عاجرلا مناخلا يء كلهتسما ماعطلا ددع وا مجد وانز
(لائملا لبيس ليلق بيلد بوك فصن صلاذ رمت تابد
تيلمع نء ديزملا تقرعمل) مجحلا تطسوتم لاقترب تءج مسدلا
يئلا عقوملا ترايزب مق لكلا رادقم نيمخت

<http://goo.gl/IQmcn>

ولافص-Description:

ماعطلا ريضحت تقيرطو مساو تيعون تباتك عاجرلا مناخلا مذهب يء
يء رضح ماعطلا ناك اذا (خلا.. يلقم قولسم يوشم) كلهتسما
ماعطلا تانوكم تباتك عاجرلا تيبلا

تافحلام-Notes:

(لائملا لبيس يء لكلا تافاضا يء تباتك عاجرلا مناخلا مذهب يء
تيز ركس بشتاك زينويا مفاضلا رادقم ديدحت عم) نوتيز

Appendix D

MedGem Instructions

Quick Start
Instructions


 **For complete instructions, read the User Guide thoroughly.**

- Plug the power cord into the MedGem® indirect calorimeter by HealthTech. Plug the DC Power Supply into a wall outlet. When the MedGem device is plugged in, it automatically turns on and starts warming up. During the warm-up, the start button flashes amber.
- The patient should be in a relaxed and rested state. For an accurate measurement, the patient should meet the pre-measurement criteria detailed in the user guide.
- If using the single-use mouthpiece
 - a. Ensure that the flow tube is completely inserted into the MedGem device.
 - b. Insert the single-use mouthpiece into the MedGem device.
- If using the mask:
 - a. Ensure that the hard-shell mask is completely inserted into the MedGem device.
 - b. Attach the soft shell mask insert onto the hard shell mask.
- Place the MedGem device on a smooth, flat surface. Press the start button to complete the self-calibration. The device will buzz softly and the start button will begin flashing amber. Do not pick up the device during self-calibration.

Instructions are continued on the back of card.

- When the MedGem device beeps once and the start button turns green, the device is ready for use.
- Place the nosedip on the patient's nose, closing the nostrils completely.
- Give the patient the MedGem device and have him/her put the mouthpiece in their mouth, ensuring a tight seal around the mouthpiece. Direct the patient to breathe normally.
- The measurement will be complete in 5 to 10 minutes. The MedGem device will signal the completion of the measurement with a single beep, and the start button will return to amber.
- At the end of the test, have the patient remove the device from the patient's mouth. Read the LCD display and record the $\dot{V}O_2$ in ml/min or the RMR in kcal/day, prior to unplugging the unit.
- To remove the single-use mouthpiece, gently twist and pull the mouthpiece from the device. Dispose of the single-use mouthpiece or mask. Ensure that the flow tube remains firmly seated in the unit. Do not discard the flow tube.



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Appendix E



Chemistry

TO: Mr. Mohammed Alquarishi
SUBJECT: Research Approval
Date: April 14, 2013

Dear Mr. Alquarishi,

It is a pleasure to tell you that your research involving human subjects has been reviewed by the Lipscomb IRB and approved. This approval means that your proposal shows that your research will meet the requirements in the federal regulations involving human subjects. This approval does not obligate any Lipscomb personnel (students, staff or faculty) to be a part of the research.

If it is necessary to make any substantial changes in your research procedures, you will need to obtain approval for these changes. If your research is not completed within twelve months, you will need to apply for a renewal of approval. We wish you well in recreating participants and in successfully completing your research project.

For the Lipscomb IRB,

A handwritten signature in cursive script that reads "William A. Tallon".

William A. Tallon, Ph. D.
Professor of Chemistry
Chairman, Lipscomb IRB

Appendix F

The Survey

Age.....

Gender.....

1. What is the highest degree or level of school you have completed?
 - High School, diploma
 - Bachelor's degree
 - Master's degree
 - Doctorate degree

2. What is your marital status?
 - Single, never married
 - Married
 - Divorced
 - Widowed
 - Separated

Indicate the extent to which you agree with each of the following statements using the following scale.

1 – strongly disagree 2 – disagree 3 – agree 4 – strongly agree

3. Your physical activity decreased during the month of Ramadan:
 - 1
 - 2
 - 3
 - 4

4. Your sleeping patterns changed during Ramadan:
 - 1
 - 2
 - 3
 - 4

THE EFFECTS OF FASTING

5. Binge eating was common during Iftar among people you know:
- 1
 - 2
 - 3
 - 4
6. Binge eating was common during Sahor among people you know:
- 1
 - 2
 - 3
 - 4
7. How many times did you exercise per week during Ramadan?
- None
 - 1-2 times
 - 2-3 times
 - 4 times or more
8. How many days did you skip fasting during Ramadan?
- None
 - 1-3 days
 - 4-6 days
 - 7-9 days
 - 10 days or more