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The Influence of Pre- and Post Meal Exercise in Relation to Postprandial Blood Glucose Levels in Type II Diabetics

Jessica Johnson
Fort Hays State University, jmjohnson3700@gmail.com

THE INFLUENCE OF PRE- AND POST MEAL EXERCISE IN RELATION TO POSTPRANDIAL BLOOD GLUCOSE LEVELS IN TYPE II DIABETICS

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ABSTRACT

The purpose of this study was to investigate the relationship of pre and post evening meal exercise in relation to postprandial blood glucose levels in type II diabetics. Fifteen participants diagnosed with type II diabetes volunteered to participate in this 21 day study. During the first seven days, participants were told to change nothing about their daily routine. Throughout the study they were asked to track all food consumption in the MyFitnessPal application and to record their blood glucose levels fasting, before their evening meal, and 120 minutes after their evening meal. At the end of day seven, each participant's carbohydrate intake was classified into the following three diets according to the American Diabetes Association: moderately low-carbohydrate diet (30-40%), moderate carbohydrate diet (40-65%) or high carbohydrate diet (> 65%). The participants were then directed to eat within their carbohydrate allowance for the remainder of the 21 days. On day eight, participants were split into the three groups: the NA group made no alterations to their daily activities, the BEM group exercised before their evening meal, and the AEM group exercised 30 minutes after their evening meal. Participants completed the study with their given treatments. Data was collected and a one-way ANOVA was performed showing statistical significance. The Tukey-Kramer Post Hoc Test was performed to investigate. Statistical significance (alpha >.05) was found between the NA vs. BEM groups and the NA vs. AEM groups, but no significance was found between the BEM vs. AEM group.

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INTRODUCTION

According to the *National Diabetes Statistics Report 2017* from the Center for Disease Control and Prevention (CDC), the prevalence of diabetes mellitus (diabetes) around the world has steadily risen to over 30.3 million, with 9.3% of all cases from the United States (Center for Disease Control and Prevention, [CDC], 2017, p. 1). A closer look at this data shows type II diabetes mellitus (type II diabetes), more commonly known as non-insulin dependent diabetes, accounting for 95% of all diagnoses. This report implies that as our nation's habits and lifestyles change, so do our health and our body's natural homeostatic mechanisms. Fox and Kilvert (2007) explained that when a person develops type II diabetes, the beta cells in the pancreas do not produce enough insulin or; in most cases, the body resists responding to sufficient levels of insulin. Insulin helps the body store glucose in the cells, so when glucose is not stored properly for the body to use for energy, the extra sugars circulate in the bloodstream allowing blood glucose levels rise. If this level rises or falls too quickly, too often, or by too much, serious health complications can arise such as retinal hemorrhaging, degenerative joint diseases, diabetic comas, or heart disease (Katch, McArdle, & Katch, 2011).

Although the consequences of type II diabetes can be severe, or even fatal, numerous studies support that physical activity and diet alterations can help lower blood glucose levels, improve insulin resistance, and aid in weight loss maintenance of type II diabetics (Guthrie & Guthrie, 2009). Dietitians suggest pairing a serving of protein with every meal, cutting back on fast digesting carbohydrates, and eating a variety of fruits and vegetables. When correct nutrition is paired with exercise, many patients lose body fat. Exercise is important because the muscles in the body burn their glycogen stores, so

they are ready to take up the glucose circulating in the blood stream (Colberg et al., 2010).

Problem Statement

While many studies have been conducted on diet and exercise, such as the Honda et al. (2016) study on stair climbing in relation to decreases in blood glucose levels or the Dempsey et al. study (2016) on brief bouts of exercise in type II diabetes, there is little information about postprandial blood glucose levels and the timing of exercise in relation to evening meal consumption. The purpose of this study was to investigate the effects of pre- and post evening meal exercise on blood glucose levels in type II diabetics.

Sub Problems

Within the problem of the study, the following sub-problems were investigated:

1. The difference in postprandial blood glucose levels between the control (NA) group and the exercise before evening meal group (BEM).
2. The difference in postprandial blood glucose levels between the control group (NA) and the exercise after evening meal group (AEM).
3. The difference in postprandial blood glucose levels between the exercise before evening meal group (BEM) and the exercise after evening meal group (AEM).

Definition of Terms

Specific terms that were used in this study included:

A1C. A test of a person's average blood glucose levels over 2 to 3 months by detecting what percentage of hemoglobin is coated with sugar; diagnoses a person with diabetes according to the following scale: non-diabetic- a person with an A1C reading of

less than 5.7%; pre-diabetic- a person with a A1C reading between 5.7%-6.4%; diabetic-a person with an A1C reading of 6.5% or higher (Diagnosing Diabetes, n.d.).

Exercise. Any planned, structured, and repetitive physical activity that requires bodily movements created by skeletal muscles that result in caloric expenditure and aid in physical fitness (Donatelle, 2013).

Fasting. Having not consumed anything for at least eight hours (Blood sugar test, n.d.).

Hyperglycemia. Also referred to as high blood glucose levels; more than 300 mg/dl (Riebe, Ehrman, Liguori, & Magal, 2018).

Hypoglycemia. Also referred to as low blood glucose levels; less than 45 mg/dL (2.5 mmol/L) with a serum insulin level of 6 microunit/mL or more (Riebe et al., 2018).

Normal meal consumption. The average caloric range and macronutrient ratio consumption based upon calculations made from the food diary recorded during week one.

Postprandial. After meal consumption; 120 minutes after evening meal consumption.

Pre-prandial. Before meal consumption.

Talk test. A field test used to help mark the intensity of exercise in relation to the ventilatory thresholds (Creemers, Foster, Porcari, Cress, & de Koning, 2017).

Target pre-prandial blood glucose levels for diabetics. 80-130 mg/dl (Checking Your Blood Glucose, n.d.).

Target postprandial blood glucose levels for diabetics. Less than 180 mg/dl (Checking Your Blood Glucose, n.d.).

Delimitations

This study focused specifically on postprandial blood glucose levels in relation to the timing of exercise; more specifically, before or after normal evening meal consumption. This study was delimited to males and females ages 45-65 years old diagnosed with type II diabetes, receiving standard medical care, who were cleared for brisk walking by his or her physician. Participants were living in Pawnee County, Barton County, or Ellis County Kansas.

Limitations

Data derived from participants may not be relevant to children or elderly people with type II diabetes. All test subjects were not consuming the same amount of calories or macronutrient ratios in relation to body composition due to the need to maintain normal eating patterns; therefore, the test could possibly not be equally replicated. More advanced measurements could be used to measure blood glucose levels than the ReliOn Prime, such as blood lab testing to eliminate the possibility of inaccuracy by the machine or participant (Zubioli et al., 2011). To increase external validity, the ReliOn Prime was used due to its accessibility and affordability. Finally, not all participants had the same daily activity levels outside of this study's exercise requirement.

Assumptions

It was assumed all test subjects would maintain normal eating and exercise habits for the duration of the test. It was also assumed that all test subjects were comfortable taking accurate blood glucose readings within the limits of the Relion Prime blood glucose meter.

Null Hypothesis

The following null hypotheses were tested at the .05 level of significance:

1. Postprandial blood glucose levels will not significantly differ due to exercise timing pre or post evening meal consumption.
2. Postprandial blood glucose levels will not significantly differ between the NA group and the BEM group.
3. Postprandial blood glucose levels will not significantly differ between the NA group and the AEM group.
4. Postprandial blood glucose levels will not significantly differ between the BEM and the AEM group.

Significance of Study

The implications derived from this study may help people with diabetes control blood glucose spikes and falls preventing the ramifications of unstable blood glucose levels such as nerve damage, blindness, insulin shock, coma, or death (Kriska, 1997). By understanding when exercise is most beneficial for a person with type II diabetes, doctors and specialists could educate patients to help prevent unnecessary doctor's visits, medication, and other expenses. Diabetes related emergency department visits totaled 14.2 million during 2014 (CDC, 2017). If that number could be reduced, the United States would save at least $123 billion dollars in health-care expenses over the span of a few years (LeRoith, Olefsky, & Taylor, 2003).

Educating people on the importance of diabetes prevention and control through diet and exercise, is important for the next generation because studies have shown a 78% positive correlation of children developing diabetes when both parents are type II

diabetics (LeRoith et al., 2004). Understanding the body's reaction to food in relation to exercise could also help people with type II diabetes lose weight and prevent obesity, which could result in helping insulin sensitivity in the future (Kriska, 1997).

REVIEW OF LITERATURE

The purpose of this study was to investigate the timing of exercise pre or post evening meal consumption in relation postprandial blood glucose levels in people with type II diabetes. This literature review will focus on explaining diabetes in greater depth, then will outline previous research done about diet and exercise in relation to blood glucose levels. Finally, it will discuss other studies conducted on lowering blood glucose levels, studies conducted on the timing of exercise, and where gaps in research are presented.

Diabetes Mellitus

According to the American Diabetes Association [ADA] (2014), "diabetes is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both" (p 1). Genetics, lifestyle, pregnancy and disease can all be factors that cause diabetes. This literature review will focus on type I diabetes and type II diabetes.

Type I. Type I diabetes, also called juvenile-onset diabetes or insulin-dependent diabetes, is the absolute deficiency of insulin secretion due to cellular mediated destruction of beta-cells. This specific type of diabetes may or may not be genetic and only accounts for around 5% of all cases of diabetes (Wardlaw, 2003). Patients are usually required to take insulin but are encouraged to use diet and exercise in conjunction with medication.

Type II. Type II diabetes, also called adult-onset diabetes and non-insulin dependent diabetes mellitus, accounts for 95% of all cases of diabetes in the United States and is characterized by individuals with impaired insulin secretion or insulin

resistance (ADA, 2014). The body produces insulin, but glucose cannot enter the cells, making blood glucose levels rise. This results in the pancreas producing great amounts of insulin until the tissues become resistant (Kriska, 1997). Type II diabetes can be diagnosed during adolescence, but most cases do not occur until later in life. These individuals are usually obese and have a sedentary lifestyle. While each person's specific needs differ, the majority are encouraged to control blood glucose levels through diet and exercise.

When the body is unable to utilize glucose in the bloodstream, it uses fat and protein for energy. Without insulin, the complete metabolism of fat is not possible; therefore, leftover particles are left in the blood stream. These particles are called ketones, and can lead to ketosis, a life threatening state (Guthrie & Guthrie, 2009). When protein is broken down, it causes muscle loss, leading to slowed metabolism that makes weight loss more difficult. This perpetuates the cycle of weight gain and muscle loss. Weight gained in the abdominal area contributes to insulin resistance; therefore, this cycle keeps overweight or obese people from losing weight while increasing the cell's resistance to insulin (Kriska, 1997). When blood glucose levels are not stable, blindness, diabetic retinopathy, diabetic chronic kidney disease, non-alcoholic fatty liver disease, gastrointestinal distress, and even death are only a few consequences that can occur (Shaw & Cummings, 2012)

Treatment of Diabetes Through Medication

The treatment of type I and type II diabetes ranges from medication to lifestyle changes. The most common categories of medications fall under a) oral hypoglycemic

agents, b) insulin, c) lipid lowering agents, d) cardiovascular agents, and e) antiplatelet agents (Dunning, 2009).

Oral hypoglycemic agents (OHA) treat different underlying mechanisms associated with glucose stabilization and are not appropriate treatment of type I diabetes. OHA requirements differ for each individual and need to be constantly monitored and changed. The main goal of this medication is to address basal secretion to keep blood glucose levels stable in between meals and during fasting states, and to address postprandial blood glucose levels (Fox & Kilvert, 2007).

Insulin therapy is used to replace absent insulin in type I diabetes and supplement insulin production in type II diabetes. Insulin is vital to controlling blood glucose levels and can be helpful to a wide variety of diabetes cases. After a meal, elevated blood glucose levels stimulate insulin to be secreted by the beta-cells in the pancreas. Once insulin is circulating in the bloodstream, it attaches to receptor sites on the cells and allows glucose to enter the cell (Fox & Kilvert, 2007).

When lipids and blood glucose levels are out of control, risk for cardiovascular disease is greatly increased. Lipid lowering agents aim to lower cholesterol and low-density lipoproteins (LDL). All lipid lowering medication should be used in conjunction with reduced salt, alcohol, and saturated fat intake; increased Omega-3 fatty acids; and increased exercise (Dunning, 2009).

Antiplatelet agents are recommended to help reduce the risk of cardiovascular disease. Aspirin is the most common antiplatelet agent, but other medications such as clopidogrel hydrochloride sulphate, dipyridamole, warfarin and heparin.may be substituted based upon a person's medical history (Dunning, 2009). Cardiovascular

agents aim to reduce or treat conditions associated with the circulatory system. While these treatments are helpful in controlling blood glucose levels and cardiovascular risks, it is widely known and documented that diet and exercise is also an avenue to help control and prevent diabetes (ADA, 2018).

Treatment/Prevention of Type II Diabetes Through Diet and Exercise

Since diabetes is a diseases directly related to the processing of food, altering sources of energy can affect blood glucose levels quickly and efficiently. According to Goff and Dyson (2015), the exact macronutrient breakdown for treating diabetes is not as important as controlling total energy intake, although the interaction of carbohydrate consumed and insulin availability can predict blood glucose reactions. Controlling energy intake can lead to weight loss, which alone can control diabetes. General eating guidelines are to consume a balanced diet, adequate in fiber, moderate in sugars, moderate carbohydrates, low in saturated fat, and adequate in protein (Sizer & Whitney, 2006). Studies have shown the generally accepted recommendation ratio of carbohydrates consumed per day to help control blood glucose levels should stay around 48% (Goff & Dyson, 2015). Carbohydrates are monitored more closely than fats and protein in a diabetic's diet because when broken down, they turn to glucose. Careful consideration needs to be given to each macronutrient to maintain a healthy weight, reduce cardiovascular disease, and maintain glucose homeostasis (Seizer & Whitney, 2006).

Studies have been conducted on the importance of exercise in controlling blood glucose levels (Colberg et al., 2010). Acute exercise causes a rapid decrease in blood glucose levels due to increased muscle sensitivity and is said to even reverse insulin resistance (Katch, et al., 2011). According to Colberg et al. (2010), as physical activity

intensities increase, the utilization of glucose increases; therefore, circulating glucose in the bloodstream is pulled to provide muscles with energy via intramuscular glycogenolysis. While resting insulin-stimulated blood glucose uptake is affected negatively by type II diabetes, muscular glucose uptake processes are not impaired.

The recommended exercise regimen for treatment of type II diabetes combines both resistance training and cardiovascular training due to greater muscular uptake of glucose. Cardiovascular training should be performed at least three days/week totaling 150 minutes per week at 40-60% of a person's maximal oxygen uptake (Vo_{2max}). Resistance training should be performed two to three times per/week utilizing moderate weight (50% of one rep max). Five – ten exercises should incorporate both upper and lower body, and repetitions should stay between 10-15. Resistance training could consequently produce muscle growth; therefore, more glucose would be taken from the bloodstream to provide energy. Acute effects of training include: improved insulin uptake 2 to 72 hours after exercise, weight loss, and improved skeletal muscle uptake of glucose. Chronic effects of exercise include: increased muscle mass, reduction of LDL and cholesterol, and lower risk of cardiovascular disease (Colberg et al., 2010). While the previous studies give insight to the importance of exercise, many questions still exist, namely when is the best time to exercise in relation to evening meal consumption for the specific purpose of controlling blood glucose levels?

Influence of Pre- and Post-dinner Exercise on Blood Glucose Levels

One study addressing postprandial exercise and postprandial blood glucose levels was conducted by Larsen, Dela, Kjer, and Galbo (1997). Nine male participants diagnosed with type II diabetes were tested to see the effects of exercise on postprandial

glucose levels. Before beginning, participants were taken through preliminary procedures such as signing waivers, accepting the terms of the study, and testing individual Vo_{2max} through a graded exercise test. In random order, with 14-18 days between trials, participants ate breakfast (56% carbohydrate, 30% fat, and 14% protein) then 45 minutes later, proceeded to exercise on an ergometer bicycle at 50% of their Vo_{2max} for 45 minutes, did not exercise and had no diet alterations, and ate breakfast with alterations lower in calories (56% carbohydrates, 30% fat, and 14% protein) respective to the participant's body weight. Results showed that postprandial exercise lowered blood glucose levels as well as diet alterations.

A study conducted in 2015 by Heden et al., tested participants to see whether pre- or post-dinner resistance exercises improved postprandial glucose and triacylglycerol (TAG) levels, risk factors for cardiovascular disease. After completing preliminary procedures (giving consent, being weighed and measured, checking health with physician), thirteen participants diagnosed with type II diabetes were given three days worth of standardized meals for the trials. A glucose monitor was inserted into the abdomen, where glucose levels were continuously recorded. In random order, participants completed the three following trials: consume an evening meal with no exercise, perform resistance exercise then consumed evening meal 30 minutes after, or consume evening meal then perform resistance exercises beginning 45 minutes after meal consumption. Blood glucose readings were taken in the morning fasting between 6:30am and 8:30am before any meal consumption, and frequently during trials. This study used the fasting blood glucose readings as the postprandial data. Blood samples were sent

through a series of tests to determine plasma TAG concentrations, free fatty acids (FFA) concentration, hematocrit, and plasma hormone concentrations.

The results showed that both pre- and post-dinner exercise reduced postprandial blood glucose levels and insulin concentrations. Post-dinner exercise improved insulin-potentiating hormones such as glucagon-like peptide 1 (GLP-1) concentrations, a hormone involved with insulin secretion. This information led Heden at. al. (2015) to conclude that post-dinner exercise is more efficient at lowering postprandial blood glucose levels, the authors noted. Further research needs to be conducted on whether this study is consistent with other trials lasting for longer periods of time.

Summary

Diabetes is a complicated disease that affects many people. Studies are being conducted to better our knowledge about what happens in the body, what type II diabetes affects, and how to personalize treatment (Fox & Kilvert, 2007). It is widely known that diet and exercise are avenues that help control blood glucose levels, but further research needs to be conducted. Previous studies about pre- and post-evening meal exercise in relation to postprandial blood glucose levels have been extremely informational, but span over only a few days (Heden et al., 2015). The aim of the current study was to address pre and post evening meal exercise and its relation to postprandial blood glucose levels over a span of two weeks. This information may fill in gaps in research and provide more information in the treatment of diabetes.

METHODS AND PROCEDURES

Introduction

The purpose of this study was to determine if pre or post evening meal exercise had an influence on postprandial blood glucose levels in type II diabetics. Both preliminary and operational procedures were used to further clarify this study after obtaining Institutional Review Board approval. The preliminary procedures discussed in this chapter will explain the organization of this study by including: subjects, instrumentation used, and research design. The operational procedures will elaborate on the exact manner in which this study was conducted by discussing: testing methods and data collection.

Preliminary Procedures

Subjects. Subjects for this study had been diagnosed with type II diabetes by a physician and were receiving standard medical care. They were healthy enough to participate in moderate walking, were able to take and read their own blood glucose levels, and were willing to track three weeks' worth of meals. They resided in Pawnee County, Barton County, or Ellis County. An informational email was sent to the staff and faculty of Fort Larned Unified School District 495 from the office of Superintendent, Mr. Joseph Sample to obtain test subjects. The email stated the purpose of the study, what was being asked of the participants if they chose to volunteer for the study, and the Principle Investigator's (PI) contact information (Appendix A). Participants voluntarily contacted the PI if they were interested in participating and were accepted if they meet the conditions stated above. Participants were excluded from the study if unexpected health complications arose such as injury or sickness due to unstable blood glucose levels

or if medication deviation occurred. Once 15 subjects volunteered to participate in the study (N=15), participants were assigned to test groups (NA=5, BEM=5, AEM=5). Participant group assignments were determined based upon the order in which they volunteered for the study. The first volunteer was assigned to the NA group, the second volunteer was assigned to the BEM group, and the third volunteer was assigned to the AEM group. The fourth volunteer was assigned to the NA group which then started the group assignment rotation, NA, BEM then AEM, again.

Instrumentation. This study required test subjects to use a blood glucose monitor. To create uniformity, all blood glucose monitors and test strips were ReliOn Prime. The ReliOn Prime blood glucose monitor is supported by the American Association of Diabetes Educators, the American Diabetes Association, the U.S. Food and Drug Administration, and the Health Industry Manufacturers Association (ARKRAY, Inc., 2011). During an accuracy test published by the Diabetes Technology Society Blood Glucose Monitor System (BGMS) Surveillance Program, the ReliOn Prime scored a 92% (Klonoff et al., n.d.).

To account for participants' varying exercise levels, the Talk Test was used as an instrument to make sure all participants were exercising at the correct intensity for their specific bodies. Participants were told to recite the Pledge of Allegiance aloud throughout the duration of their walks (Ace-Sponsored Research, n.d.). This kept participants exercising at the correct intensity levels. The Talk Test has been shown to correlate with the ventilatory thresholds of pulmonary ventilation. Exercise performed below the first threshold generally allows participants to speak comfortably. Once speaking becomes uncomfortable and participants are not able to recite paragraphs, participants approach

Ventilatory Threshold 1. As exercise intensity increases, participants become more and more uncomfortable speaking. Once participants cannot speak more than a few words and speaking becomes obviously labored, they begin to approach Ventilatory Threshold 2. Speaking becomes impossible after reaching Ventilatory Threshold 2 (Porcari, Bryant, & Comana, 2015). According to Nielson et al. (2015), the Talk Test is an inexpensive, simple tool efficient at analyzing exercise intensities, and has been found to correlate with the different ventilatory thresholds in both sedentary people and elite athletes. The Talk Test accounted for external validity due to its simplicity and easy accessibility to the public.

The application, MyFitnessPal, was used to track food consumption for the duration of the study. The Journal of the Dietitians Association of Australia published a study to determine the validity of MyFitnessPal and concluded that the application was accurate in recording fiber and energy intake (Teixeira,Voci, Mendes-Netto, & Silva, 2017).

Research Design. The purpose of this study was to determine if pre or post evening meal exercise had an influence on postprandial blood glucose levels in type II diabetics. The independent variable in this test was the time of exercise in relation to evening meal consumption. The dependent variable was the postprandial blood glucose level measured 120 minutes after meal consumption. There was one control group and two experimental groups; therefore, this test was conducted using the three-group parallel group design (Chow & Liu, 2014). The control group made no alterations to their daily activity while one group performed exercise before their evening meal and the other

performed exercise after their evening meal. The duration of this test was 21 days to ensure the results were re-occurring over a period of time.

To account for internal validity, subjects recorded average food intake using the application, MyFitnessPal, during week one before the treatment was administered. From this, each person's average caloric consumption and macronutrient percentages were calculated the evening of day seven. Participants continued to track their food intake for the rest of the testing period matching average macronutrient and caloric consumption. This accounted for any diet alterations. All instruments used while testing were accessible to the public.

Operational Procedures

Testing methods. Before testing began, subjects were sent a second email about the parameters of the study (Appendix B). Participants met with the PI to discuss any questions they had. During this meeting, informed consent waivers, participant approval, and instrumentation competency documents were discussed. Time was allotted to answer any question participants had. After all the information had been presented, participants signed an informed consent document stating they understood the parameters of the study, what was being asked of them, and that they were free to withdrawal from the study at any time (Appendix C).

Participants signed a waiver stating they had been diagnosed with type II diabetes by a physician, had been receiving standard medical care, and were healthy enough to participate in moderate walking (Appendix D). Participants signed a waiver stating they understood how to use the instruments provided (Appendix E). Once all paperwork was signed, the ReliOn Prime blood glucose monitor, the ReliOn Prime blood glucose strips,

and the MyFitnessPal application information was provided to the subjects. Participants were told that if they wanted more information on the study to contact the PI after the study was completed via e-mail.

During week one, subjects were split into the following three groups: 1) control group NA group 2) exercise before evening meal (BEM) group, and 3) exercise after evening meal group (AEM) group. Subjects were asked to record all the food they ate through the application, MyFitnessPal. Participants were asked to eat as normally to their regular eating patterns as possible. Subjects tried not to eat less, at different times of the day, or in different ratios throughout the three-week study. Participants were asked to record their fasting blood glucose levels before breakfast, before their evening meal, and 120 minutes post evening meal consumption.

At the end of week one, each participant's average caloric consumption and macronutrient ratios were calculated from week one's food-log in MyFitnessPal. Participants' carbohydrate percentage intake were classified as a moderately low-carbohydrate diet (30%-40%), a moderate carbohydrate diet (40%-65%) or a high carbohydrate diet (> 65%) according to the American Diabetes Association standards (Wheeler et al., 2012). Participants were asked to match the carbohydrate macronutrient ratio range throughout the rest of the study.

During weeks two and three, subjects tracked their food consumption throughout the day in the MyFitnessPal application to record that they were eating within their normal carbohydrate range as determined from week one. They recorded their fasting blood glucose levels before breakfast, before evening meal consumption, and 120 minutes after evening meal consumption.

The exercising groups performed 30 minutes of walking between Ventilatory Threshold 1 and Ventilatory Threshold 2 as measured by the Talk Test. The BEM group exercised for 30 minutes then immediately consume their evening meal. They recorded their blood glucose levels 120 minutes after eating. The AEM group consumed their evening meal then immediately walked for 30 minutes. They took their blood glucose levels 90 minutes after exercising. All groups participated under their assigned condition for two weeks.

Data Collection. The data was recorded by the PI on a data sheet (Appendix F). Postprandial blood glucose data was analyzed by a one-way analysis of variance (ANOVA) using Microsoft Office Professional Plus 2016 Excel. All data was analyzed at 0.5 level of significance. When the data indicated significance, the Tukey-Kramer post hoc test was administered to find where the significance was located.

RESULTS AND DISCUSSION

The purpose of this study was to investigate the relationship between the timing of exercise and evening meal consumption on blood glucose levels in people with type II diabetes. This 21-day investigation focused on 15 participants residing in Ellis, Barton, or Pawnee County between the ages of 18 and 65 diagnosed with type II diabetes mellitus. Participants were asked to record all meal consumptions as well as their blood glucose levels fasting, pre-prandial, and postprandial throughout the duration of the study. During the first week of the study, participants made no alterations to their daily routine. During week 2 and 3, participants a) exercised for thirty minutes before evening meal consumption, b) exercised for thirty minutes after evening meal consumption, or c) did not add any exercise to their daily routine.

Data pertaining to this investigation were recorded on the data sheet provided by the PI then were transferred to a data analysis system on a computer (Appendix G). Descriptive data were obtained for the no alteration group (n=5), before evening meal group (n=5), and the after evening meal group (n=5) days 1-7, and days 8-21. A one-way ANOVA was used to compare the NA, BEM, and AEM postprandial blood glucose data. The alpha level was set at the .05 level of significance. The Tukey- Kramer Post Hoc Test was performed to compare the postprandial blood glucose data of the NA group to the BEM group, the NA group to the AEM group, and the BEM group to the AEM group. Data presented are shown in Tables 1, 2 and 3 on the following pages.

Results

Table 1

Descriptive Data

Days 1-7	*Group*		*Mean*	*SD*	*Range*
	NA				
		Fasting	122	19	82
		Pre-prandial	115	27	116
		Postprandial	117	28	143
	BEM				
		Fasting	149	43	179
		Pre-prandial	132	34	133
		Postprandial	201	59	201
	AEM				
		Fasting	152	59	257
		Pre-prandial	150	56	263
		Postprandial	201	98	487
Days 8-21					
	NA				
		Fasting	121	18	109
		Pre-prandial	123	4	214
		Postprandial	119	29	166
	BEM				

	Fasting	148	45	290
	Pre-prandial	134	42	315
	Postprandial	173	79	538
AEM				
	Fasting	155	55	279
	Pre-prandial	149	53	272
	Postprandial	202	96	495

The descriptive data showed that the NA group had lower fasting blood glucose levels, smaller standard deviation, and smaller range than the BEM and AEM groups throughout the entirety of the study. During days 1-7 participants made no alterations to their daily activities. The descriptive data shows the NA group having slightly lower fasting and pre-prandial blood glucose levels, and much lower postprandial blood glucose levels during days 1-7. During days 8-21, the NA group had lower fasting blood glucose levels than the BEM and AEM groups, but similar pre-prandial blood glucose levels. The postprandial blood glucose levels during days 8-21 of the BEM and AEM group were higher than the NA group.

During days 8-21, the BEM group's postprandial blood glucose levels ranged 538 points, the AEM group's postprandial blood glucose levels ranged 495 points, and the NA group's postprandial blood glucose levels ranged. Overall, participants in the BEM and AEM groups had less controlled blood glucose levels than the NA group.

Table 2

Results of ANOVA: Comparison of Postprandial Blood Glucose Levels

Source	*SS*	*Df*	*MS*	*F value*	*P-value*	*F-critical*
Between Group	307919.6	2	153959.8	31.854	8.685E-13	3.039

Hypothesis 1. Postprandial blood glucose levels did not significantly differ due to exercise timing pre or post evening meal consumption. Therefore, the null hypothesis was rejected; p-value of 8.685E-13 < .05, F-value of 31.854 > F-critical value 3.0395. The Tukey-Kramer Post Hoc Test was then administered.

Table 3

Tukey-Kramer Post Hoc Test

Group	*Difference*	*n Group 1*	*n Group 2*	*SE*	*q*
NA vs BEM	78.6143	70	70	8.3095	9.4609
NE vs AEM	83.6143	70	70	8.3095	10.062
BEM vs AEM	5	70	70	8.3095	0.6017

Hypothesis 2. The mean difference was analyzed at the alpha level of .05. The critical q-value was 3.31. Therefore, the q-value of the NA and BEM group was 9.4609 > critical q-value of 3.31. H_2: Postprandial blood glucose levels did not significantly differ between the control group and the exercise before evening meal group. Therefore, the null hypothesis was rejected. Statistical significance was discovered between postprandial

blood glucose levels between the NA group (mean=119) and the BEM group (mean=173).

Hypothesis 3. The mean difference was analyzed at the alpha level of .05. The critical q-value was 3.31. Therefore, the q-value of the NA and AEM group was 10.062 > critical value of 3.31. H_3: Postprandial blood glucose levels did not significantly differ between the control group and the exercise after evening meal group. Therefore, the null hypothesis was rejected. Statistical significance was discovered between postprandial blood glucose levels between the NA group (mean=119) and the AEM group (mean=202).

Hypothesis 4. The mean difference was analyzed at the alpha level of .05. The critical q-value was 3.31. Therefore, the q-value of the BEM and AEM group was 0.6017 < critical q-value 3.31. H_4: Postprandial blood glucose levels did not significantly differ between the exercise before evening meal group and the exercise after evening meal group. As a result, the null hypothesis was retained. Therefore, no statistical significance differences existed in postprandial blood glucose levels between the BEM group (mean=173) and AEM group (mean=202).

Discussion

The purpose of this study was to determine if the timing of exercise in relation to evening meal consumption had an effect on postprandial blood glucose levels in people with type II diabetes. Data was analyzed and showed statistical significance after running the ANOVA test. The Tukey-Kramer Post Hoc Test was then performed when significance was indicated to determine where statistical significance existed. While the ANOVA test compared the means of each group, it is possible that a different statistical

test could be used to better encompass the extremes of data set. Average blood glucose ranges for people with type II diabetes usually fall within 250-300 points, so it was unforeseen that any participant's blood glucose would range 538 points.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the relationship between the timing of exercise and evening meal consumption on blood glucose levels in people with type II diabetes. Statistical results showed there was significance in the comparison of the NA, BEM, and AEM groups. H_1: Postprandial blood glucose levels will not significantly differ due to exercise timing pre or post evening meal consumption was rejected. The Tukey-Kramer Post Hoc Test was performed and discovered significance between the NA and BEM group and the NA and AEM group; but not between the BEM and AEM group. H_2: Postprandial blood glucose levels will not significantly differ between the control group, and H_3: Postprandial blood glucose levels will not significantly differ between the control group and the exercise after evening meal group were rejected. Ho4: Postprandial blood glucose levels will not significantly differ between the exercise before evening meal group and the exercise after evening meal group, was retained. Therefore, it is concluded that the timing of exercise in relation to evening meal consumption may not significantly affect postprandial blood glucose levels. It is also concluded that any exercise at any time of the day may significantly affect postprandial blood glucose levels.

Descriptive data showed the BEM and AEM groups had an overall higher mean of blood glucose levels fasting, pre-prandial, and postprandial throughout the study than the NA group. The BEM and AEM groups also had a greater range and standard deviation. Although previous studies have indicated exercise decreasing appetite, it is possible that the AEM group and the BEM group ate more food due to increased energy

expenditure when performing exercise (Douglas et al., 2016). This might account for the increased overall blood glucose levels.

Although this study accounted for external validity by using instrumentation that was easily obtainable, there is a need for greater internal validity. This study required participants to take their own blood glucose readings. Although each participant was competent in safely taking glucose readings, the internal validity of this procedure may have been less accurate than if readings were taken and read in a lab by a professional.

Another area that faced limitations was the accuracy of the prescribed exercise. Participants were told to exercise between VT1 and VT2 using the Talk Test. While this test was cost effective and easily understood by participants, Vo_{2max} testing in an exercise lab followed by monitored exercise would have been a more accurate.

Other limitations faced in this study was having a small n-number (n) to account for statistical power. Criteria for participation in this study limited subjects to a specific population. This population already had a predisposition for being sedentary, so finding participants that were willing to exercise created an even smaller pool of people willing to participate.

Conclusions

Statistical findings of this study support the literature reviewed pertaining to completion of this study. This study analyzed only blood glucose levels. Heden et al. (2015) concluded that post evening meal exercise was more efficient in lowering blood glucose levels due to the increase of the GLP-1 hormone, but also concluded that any exercise, pre- or postprandially, may effectively lower blood glucose levels. Other studies

concluded that exercise of any type at any time of the day, are effective in lowering blood glucose levels (Katch, et al., 2011).

Implications from this study may help healthcare professionals and exercise professionals in prescribing exercise regimes to type II diabetic patients. This study illustrated that the time of day exercise is performed around evening meal consumption has little effect on blood glucose levels. People with type II diabetes already exercising would not have to alter their daily habits because the study implies that any exercise introduced into a daily routine could have an effect on blood glucose levels. People with type II diabetes not exercising could receive guidelines to incorporate exercise anytime throughout the day.

Recommendations for Future Studies

The following are recommendations for future studies: (a) utilize laboratory blood testing rather than blood glucose monitors, (b) base exercise prescription upon participant's Vo_{2max}, (c) include type I diabetics as subjects, and (d) consider using more in-depth statistical testing. Future studies focused on the timing of exercise around evening meal consumption with a more exhaustive blood analysis panel could be conducted to derive more accurate data. Exercise prescription based upon an individual's Vo_{2max} and laboratory monitoring during exercise could help increase internal validity. Other areas of interest derived from this study could be the effects of exercise timing around evening meal consumption and fasting blood glucose levels in type II diabetics and type I diabetics. Finally, more sophisticated statistical tests, such as a two way ANOVA or ANCOVA, could be used to help account for large ranges of blood glucose levels.

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Appendix A

First Email to Staff

Email to the USD 495 staff for volunteer participation

Project Title: The Influence of Pre- and Postdinner Exercise in Relation to Postprandial Blood Glucose Levels in Type II Diabetics

Primary Investigator: Jessica Johnson, BGS

Faculty & Staff of USD 495,

I hope you are all doing well this semester! My name is Jessica Johnson, a 2014 graduate of Larned High School and the daughter of Jerry & Jeanette Johnson. I currently attend Fort Hays State University and am working on my thesis for my Master's Degree in Exercise Science.

I am reaching out to the faculty and staff of Unified School District 495 in regards to helping me obtain volunteer participants for my study on exercise timing and type II diabetes mellitus. Many studies have been conducted about the effects of exercise and blood glucose levels in type II diabetics, but little information is known about the **timing** of exercise.

Participants of this study will receive a new blood glucose reader and blood glucose test strips. Activities required of participants will be tracking blood glucose levels, and brisk walking for 21 days.

Again, this is completely voluntary! If you are type II diabetic (diagnosed by a physician) interested in possibly helping me with my thesis, please contact me at 620-

804-3442 or jmjohnson26@mail.fhsu.edu. If you have any friends that would also be willing to participate, feel free to give them my contact information.

Thank you for your time,

Jessica Johnson

Appendix B

Second Email to Staff

Project Title: The Influence of Pre- and Postdinner Exercise in Relation to Postprandial Blood Glucose Levels in Type II Diabetics

Primary Investigator: Jessica Johnson, BGS

Hello! My name is Jessica Johnson, and I will be the principle investigator on this project. I am currently a student at Fort Hays State University and am getting my Master's Degree in Health and Human Performance with an emphasis in Exercise Science. As part of my curriculum, I have chosen to conduct a thesis experiment over the effects of blood glucose levels and exercise timing in relation to meal consumption.

I would like to thank you for volunteering to participate in this study. At this time I would like to provide you with more in-depth information about the study and what is being asked of you.

This study will last for 21 days. During those days you will be asked to track your food intake through MyFitnessPal, perform brisk walking, and take/track your blood glucose levels. During our in person meeting, you will sign an informed consent waver stating you understand the parameters of the study, what is being asked of you, and that you are free to abstain from the study at any time. You will also sign a waver stating you have been diagnosed with type II diabetes by a physician, are receiving standard medical care, and are healthy enough to participate in moderate walking.

Procedures:

During week one, you will be asked to record all food consumption through the application, MyFitnessPal. You will be asked to eat as consistently to your normal eating patterns as possible. You should not try to eat less, at different times of the day, or in different ratios throughout the three-week study. You will be asked to record your fasting blood glucose levels before breakfast, before your evening meal, and 120 minutes post meal consumption.

At the end of week one, your average caloric consumption and macronutrient ratios will be calculated from week one's food-log in MyFitnessPal. You will then be asked to match the macronutrient ratio throughout the rest of the study.

At the beginning of week two, you will be split into one of the following three groups: 1) the no exercise alteration group (NE) 2) the group that exercise before evening meal (BEM), and 3) the group that exercises after their evening meal (AEM). You will continually track your food consumption in MyFitnessPal to show you are not making drastic alterations to your normal eating patterns. You will continue to record your fasting blood glucose levels before breakfast, before evening meal consumption, and 120 minutes after meal consumption.

If you are in the exercising groups, you will perform 30 minutes of brisk walking using the Talk Test meaning you will exercise at an intensity where you can talk short phrases, but not full paragraphs. The best way to monitor this is by saying the Pledge of Allegiance. Reciting the Pledge of Allegiance aloud throughout your walk, even if you are walking by yourself, will help you exercise at the correct intensity. This will keep your intensity walking between the Ventilatory Threshold 1 (VT1) and Ventilatory Threshold 2 (VT2). VT1 is where your body begins to need more oxygen and VT2 is

where your body begins to accumulate lactate. If you are in the BEM group, you will exercise for 30 minutes then wait 30 minutes before consuming your evening meal. Directly after meal consumption, you will wait 120 minute then will record your blood glucose levels. If you are in the AEM group, you will consume your evening meal then will wait 30 minutes before beginning 30 minutes of a brisk walk between VT1 and VT2. You will then take your blood glucose levels 120 minutes directly after meal consumption. All groups will participate under the given condition for two weeks.

Please respond to this email indicating if you would still like to participate in this study. If so, we will schedule a time to meet in person where we will go over informed consent, physician approval, and instruments.

If you have any questions, please contact me at 620-804-3442 or jmjohnson26@mail.fhsu.edu

Thank you for your time,

Jessica Johnson

Appendix C

Informed Consent Statement

THE INFLUENCE OF PRE- AND POSTDINNER EXERCISE IN RELATION TO POSTPRANDIAL BLOOD GLUCOSE LEVELS IN TYPE II DIABETICS

INTRODUCTION

The Department of Health and Human Performance at Fort Hays State University supports the practice of protection for human subjects participating in research. **You are being asked to participate in a research study. It is your choice whether or not to participate.** The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with this unit, the services it may provide to you, or Fort Hays State University.

PURPOSE OF THE STUDY

The object of this study will be to determine if long-term (21 days) pre or post meal exercise has an influence on postprandial blood glucose levels in type 2 diabetics.

PROCEDURES

Before testing begins, an informational video will be given to you on the parameters of the study, how to correctly use instruments provided, and how to correctly record data on the table given. After you have viewed the video, you will sign an informed consent waiver stating you understand the parameters of the study, what is being asked of you, and that you are free to abstain from the study at any time. You will

sign a waiver stating you have been diagnosed with type II diabetes by a physician, are receiving standard medical care, and are healthy enough to participate in moderate walking. You will also sign a waiver stating you understand how to use the instruments provided.

During week one, you will be asked to record all food consumption through the application, MyFitnessPal. You will be asked to eat as consistently to your normal eating patterns as possible. You should not try to eat less, at different times of the day, or in different ratios throughout the three-week study. You will be asked to record your fasting blood glucose levels before breakfast, before your evening meal, and 120 minutes post meal consumption.

At the end of week one, your average caloric consumption and macronutrient ratios will be calculated from week one's food-log in MyFitnessPal. You will then be asked to match the macronutrient ratio throughout the rest of the study.

At the beginning of week two, you will be split into one of the following three groups: 1) the no exercise alteration group (NE) 2) the group that exercise before evening meal (BEM), and 3) the group that exercises after their evening meal (AEM). You will continually track your food consumption in MyFitnessPal to show you are not making drastic alterations to your normal eating patterns. You will continue to record your fasting blood glucose levels before breakfast, before evening meal consumption, and 120 minutes after meal consumption.

If you are in the exercising groups, you will perform 30 minutes of brisk walking using the Talk Test meaning you will exercise at an intensity where you can talk short phrases, but not full paragraphs. This will keep your intensity walking between the

Ventilatory Threshold 1 (VT1) and Ventilatory Threshold 2 (VT2). If you are in the BEM group, you will exercise for 30 minutes then wait 30 minutes before consuming your evening meal. Directly after meal consumption, you will wait 120 minute then will record your blood glucose levels. If you are in the AEM group, you will consume your evening meal then will wait 30 minutes before beginning 30 minutes of a brisk walk between VT1 and VT2. You will then take your blood glucose levels 120 minutes directly after meal consumption. All groups will participate under the given condition for two weeks.

If you decide to participate in this research study, you will be asked to sign this consent form after you have had all of your questions answered and understand what will happen to you. The length of time of your participation in this study is 21 days. Approximately 15 participants will be in this study.

RISKS

Although no foreseeable risks are associated with this study, extreme blood glucose levels could cause health issues. Due to the nature of this study, all participants will be physician diagnosed type II diabetics; therefore, all blood draws to test blood glucose levels will be routine to the participants.

BENEFITS

By understanding when exercise is most effective in relation to blood glucose levels, death and medical complications could be avoided and lowered. By using exercise as a supplement to medication or to replace medication, you could avoid possible pharmaceutical side effects of prescribed drugs. Having few doctors' visits and less medication could potentially reduce the cost of being diabetic. These benefits are

substantial in improving the quality of life of type II diabetics. Although some risks are present, exercise is an inexpensive, safe alternative to pharmaceuticals.

PAYMENT TO PARTICIPANTS

You will receive a ReliOn Plus blood glucose meter, and ReliOn Plus blood glucose test strips. Instruments will be provided during the initial meeting after signing a waiver stating you understand how to use them instruments correctly.

PARTICIPANT CONFIDENTIALITY (HOW WILL PRIVACY BE PROTECTED)

Your name will not be associated in any publication or presentation with the information collected about you or with the research findings from this study. Instead, the researcher(s) will use a study number or a pseudonym rather than your name. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your information for purposes of this study at any time in the future.

OTHER IMPORTANT ITEMS YOU SHOULD KNOW

· **Withdrawal from the study:** You may choose to withdraw from this study at any time without risk of penalty.

· **Funding:** The Graduate Scholarly Experience Grant at Fort Hays State University will be providing funding for this research.

· **Alternative options:** Participating in this study is completely voluntary.

INSTITUTIONAL DISCLAIMER STATEMENT

The event of injury, the Kansas Tort Claims Act provides for compensation if it can be demonstrated that the injury was caused by the negligent or wrongful act or omission of a state employee acting within the scope of his/her employment.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from Fort Hays State University or to participate in any programs or events of Fort Hays State University. However, if you refuse to sign, you cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to participate in this study at any time. You also have the right to cancel your permission to use and disclose further information collected about you, in writing, at any time, by sending your written request to: Jessica Johnson, 620-804-3442, jmjohnson26@mail.fhsu.edu

If you cancel permission to use your information, the researchers will stop collecting additional information about you. However, the research team may use and disclose information that was gathered before they received your cancellation, as described above.

QUESTIONS ABOUT PARTICIPATION

Questions about procedures should be directed to the researcher(s) listed at the end of this consent form.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study. I understand that if I have any additional questions about my rights as a research participant, I may call (785) 628-4349, write the Office of Scholarship and Sponsored Projects (OSSP), Fort Hays State University, 600 Park St., Hays, Kansas 67601, or email irb@fhsu.edu.

I agree to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

_____ _____

Type/Print Participant's Name Date

_____

Participant's Signature

RESEARCHER CONTACT INFORMATION:

Jessica Johnson & John Zody, Ed.D.

Principal Investigator Faculty Supervisor

Department of HHP Department of HHP

600 Park St. 600 Park St.

Fort Hays State University Fort Hays State University

Hays, KS 67601 Hays, KS 67601

(785) 628-5555 (785) 628-5555

Appendix D

Participant Approval

I_____, certify that I have been diagnosed with type II diabetes mellitus by a physician, am receiving standard medical care, and am healthy enough to participate in moderate walking.

Signature:_____ Date:_____

Appendix E

Instrumentation Competency Form

I _____have participated in an informational training session and understand how to use the RELION PRIME blood glucose reader and RELION PRIME blood glucose test strips. I have received the RELION PRIME blood glucose reader and the RELION PRIME test strips provided for me and understand that any damage to the instruments will result in a fine towards me. I understand that I will be required to track my blood glucose levels accurately, and any falsification will have me dismissed from this study.

Date:

Signature (print):

Signature:

Appendix F

Data Reporting Sheet

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1						
2						
3						
4						
5						
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21						

Appendix G

Participant Blood Glucose and Macronutrient Records

Table 1

BEM Participant 1

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	226	184	236	25	20	55
2	144	198	243	35	25	40
3	162	220	196	29	23	48
4	136	132	322	28	28	44
5	97	90	239	31	42	27
6	82	187	142	26	45	29
7	73	92	277	53	23	24
8	106	160	254	37	32	31
9	147	121	312	44	32	24
10	165	115	274	36	41	23
11	146	137	205	36	35	29
12	156	78	235	32	42	26
13	134	96	227	21	44	35
14	143	143	258	29	40	31
15	135	103	198	46	37	17
16	132	83	288	38	22	40
17	256	219	367	30	31	39
18	193	89	212	32	42	26
19	127	189	304	18	66	16
20	136	166	255	20	55	25
21	144	99	233	33	64	3

Table 2

BEM Participant 2

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	151	189	173	26	37	37
2	106	113	206	18	27	55
3	118	98	259	19	35	46
4	125	127	139	24	35	41
5	134	145	136	17	32	51
6	95	152	144	31	12	57
7	127	151	122	41	21	38
8	97	169	159	16	37	47
9	117	109	100	28	25	47
10	85	122	184	29	31	40
11	85	157	154	21	38	41
12	114	169	133	20	33	47
13	152	135	219	18	33	49
14	104	164	167	25	41	34
15	128	102	121	27	33	40
16	90	156	136	18	44	38
17	92	136	153	18	39	43
18	80	158	128	21	37	42
19	85	113	124	21	48	31
20	113	146	158	24	33	43
21	126	175	132	34	13	53

Table 3

BEM Participant 3

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	247	128	272	26	35	39
2	252	164	264	18	38	44
3	225	145	225	30	26	44
4	188	114	314	31	19	50
5	229	117	226	24	36	40
6	154	89	158	30	31	39
7	152	87	244	24	35	41
8	159	113	172	26	32	42
9	141	111	209	28	24	48
10	158	92	171	29	33	38
11	160	121	282	26	28	46
12	166	140	233	28	31	41
13	132	105	220	12	23	65
14	135	86	228	15	30	55
15	89	79	233	20	30	50
16	129	135	211	21	32	47
17	146	104	157	19	24	57
18	133	107	111	28	31	41
19	125	151	231	9	40	51
20	104	176	250	20	20	60
21	155	100	149	18	12	70

Table 4

BEM Participant 4

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	132	101	121	21	20	59
2	128	111	156	30	25	45
3	144	98	132	29	38	33
4	142	103	156	20	24	56
5	124	90	132	25	19	56
6	124	95	151	14	24	62
7	126	152	179	23	25	52
8	131	103	115	27	26	47
9	157	120	112	25	20	55
10	147	226	177	19	17	64
11	146	83	103	17	37	46
12	156	122	82	14	24	62
13	159	117	96	18	20	62
14	157	188	135	16	34	50
15	158	136	161	20	18	62
16	160	95	93	26	31	43
17	162	113	118	24	12	64
18	146	96	215	15	24	61
19	142	95	99	22	14	64
20	138	135	121	20	14	66
21	47	42	140	18	20	62

Table 5

BEM Participant 5

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	156	127	143	22	63	15
2	146	127	207	13	59	28
3	137	126	218	14	39	47
4	144	131	142	23	46	31
5	164	140	238	14	47	39
6	156	138	299	14	61	25
7	164	144	223	26	47	27
8	155	129	299	26	47	27
9	154	156	158	21	55	24
10	169	145	212	33	42	25
11	150	162	260	7	33	60
12	152	132	195	21	44	35
13	161	140	282	18	55	27
14	172	124	307	13	50	37
15	175	123	225	19	51	30
16	162	142	291	20	41	39
17	172	149	270	13	43	44
18	152	105	296	8	54	38
19	165	115	248	19	53	28
20	163	143	230	13	53	34
21	158	227	231	15	49	36

Table 6

AEM Participant 1

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	104	151	127	23	25	52
2	127	178	157	22	25	53
3	148	105	125	26	19	55
4	131	95	112	20	16	64
5	126	122	114	19	22	59
6	131	144	121	28	22	50
7	151	99	200	16	18	66
8	112	109	113	28	22	50
9	109	143	151	30	22	48
10	129	177	102	18	16	66
11	100	90	151	28	15	57
12	121	116	178	28	17	55
13	133	171	120	32	24	44
14	141	158	127	30	17	53
15	130	92	109	23	24	53
16	154	94	146	19	24	57
17	125	110	236	18	11	71
18	58	172	98	29	19	52
19	141	127	130	22	23	55
20	123	116	123	27	21	52
21	147	127	176	32	24	44

Table 7

AEM Participant 2

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	122	127	102	26	48	26
2	154	105	113	25	41	34
3	132	115	107	19	53	28
4	121	103	100	22	38	40
5	124	94	131	18	47	35
6	135	131	156	10	45	45
7	144	164	188	13	41	46
8	147	90	92	20	34	46
9	118	97	161	15	50	35
10	130	89	190	21	36	43
11	142	168	137	21	46	33
12	131	114	107	19	41	40
13	138	166	203	13	42	45
14	145	131	119	18	42	40
15	121	101	108	16	48	36
16	108	91	97	20	38	42
17	107	99	172	19	44	37
18	122	118	221	17	46	37
19	137	141	240	17	44	39
20	149	103	217	16	51	33
21	165	186	209	16	46	38

Table 8

AEM Participant 3

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	290	357	428	33	27	40
2	156	164	336	26	25	49
3	165	274	315	15	27	58
4	131	157	587	32	26	42
5	256	208	250	32	16	52
6	313	169	234	35	16	49
7	355	251	265	35	15	50
8	206	222	288	14	39	47
9	241	122	360	7	26	67
10	288	168	288	26	36	38
11	256	129	353	18	30	52
12	337	102	486	12	32	56
13	251	204	402	18	34	48
14	226	184	320	32	33	35
15	244	198	243	16	16	68
16	290	357	428	29	22	49
17	178	164	336	15	32	53
18	190	274	315	31	30	39
19	208	303	587	33	27	40
20	256	201	250	20	37	43
21	313	169	347	14	46	40

Table 9

AEM Participant 4

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	103	128	166	11	44	45
2	144	163	196	28	25	47
3	135	102	155	12	32	56
4	100	94	207	14	31	55
5	98	130	245	16	43	41
6	140	143	187	32	29	39
7	133	154	199	34	24	42
8	181	127	149	21	35	44
9	123	131	173	7	16	77
10	172	129	247	21	37	42
11	109	144	220	35	27	38
12	188	185	185	38	26	36
13	143	106	147	46	18	36
14	97	85	189	12	16	72
15	109	150	202	15	28	57
16	144	99	144	21	35	44
17	157	137	159	34	24	42
18	127	97	129	32	29	39
19	143	152	199	33	23	44
20	128	198	265	20	15	65
21	111	122	156	24	20	56

Table 10

AEM Participant 5

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	128	127	219	12	39	49
2	123	113	240	16	41	43
3	164	108	196	30	30	40
4	135	191	159	15	41	44
5	138	137	210	24	34	42
6	151	184	218	12	42	46
7	117	167	163	17	32	51
8	144	193	128	22	40	38
9	142	131	163	20	37	43
10	113	164	168	18	19	63
11	132	164	145	21	41	38
12	112	172	136	24	35	41
13	144	210	162	15	38	47
14	162	114	185	12	33	55
15	128	123	148	18	42	40
16	123	139	138	18	33	49
17	139	297	197	11	59	30
18	126	161	191	19	48	33
19	144	152	158	15	23	62
20	140	115	226	16	65	19
21	119	121	223	21	42	37

Table 11

NA Participant 1

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	103	113	74	15	33	52
2	102	195	126	33	40	27
3	124	158	55	12	36	52
4	127	121	85	24	39	37
5	100	140	86	23	29	48
6	96	90	133	21	25	54
7	91	165	65	14	24	62
8	117	84	84	14	21	65
9	105	128	49	12	37	51
10	176	147	49	17	35	48
11	111	122	89	16	35	49
12	84	127	109	11	39	50
13	109	124	136	17	15	68
14	97	170	156	17	17	66
15	118	109	114	21	33	46
16	108	200	70	22	54	24
17	109	142	110	7	33	60
18	118	139	126	45	29	26
19	104	145	96	21	21	58
20	109	94	70	19	37	44
21	130	298	102	25	24	51

Table 12

NA Participant 2

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	128	98	94	14	21	65
2	147	91	155	23	24	53
3	126	105	113	16	32	52
4	124	81	156	22	34	44
5	129	79	126	7	47	46
6	149	93	107	10	37	53
7	105	104	154	18	30	52
8	124	84	160	6	31	63
9	137	158	134	11	29	60
10	140	130	164	5	34	61
11	133	94	162	16	34	50
12	132	105	127	16	34	50
13	131	104	90	39	19	42
14	138	103	128	32	20	48
15	135	126	117	5	39	56
16	130	102	120	19	26	55
17	135	114	130	19	41	40
18	131	120	127	15	22	63
19	144	108	120	14	30	56
20	134	110	137	14	37	49
21	134	116	124	21	33	45

Table 13

NA Participant 3

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	127	113	108	17	43	40
2	130	109	103	23	34	43
3	122	100	132	14	44	42
4	116	82	127	16	44	40
5	121	97	130	8	29	63
6	119	104	198	13	45	42
7	125	112	102	18	38	44
8	119	102	142	14	35	51
9	134	130	121	19	31	50
10	112	105	124	19	32	49
11	123	119	148	8	62	30
12	122	129	154	15	25	60
13	124	114	129	20	33	47
14	119	130	101	16	35	49
15	131	110	108	26	23	51
16	127	120	101	13	32	55
17	112	113	114	30	48	22
18	117	139	77	11	36	53
19	67	134	103	14	42	44
20	125	106	108	13	28	59
21	114	106	128	17	36	47

Table 14

NA Participant 4

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	100	99	116	16	51	33
2	102	89	138	23	63	14
3	101	100	114	11	51	38
4	104	110	135	25	42	33
5	97	131	97	7	29	64
6	115	135	106	17	65	18
7	110	112	85	10	44	46
8	95	105	135	20	19	61
9	105	118	108	15	46	39
10	106	93	101	23	59	18
11	110	101	140	13	48	39
12	96	119	110	11	43	46
13	101	107	128	27	37	36
14	92	118	106	8	43	49
15	101	128	102	11	52	37
16	93	119	101	19	47	34
17	97	117	153	10	42	48
18	120	107	134	8	34	58
19	103	103	94	14	44	42
20	118	95	109	16	44	40
21	117	109	125	15	48	37

Table 15

NA Participant 5

Day	BG Fasting	BG Before Evening Meal	BG After Evening Meal	% Protein	% Fat	% Carbs
1	147	173	125	14	22	64
2	173	118	129	12	12	76
3	145	120	114	15	20	65
4	140	109	102	22	15	63
5	139	123	142	23	22	55
6	136	119	128	11	29	60
7	153	144	121	11	30	59
8	121	219	123	21	16	63
9	135	121	80	22	36	42
10	124	94	146	17	18	65
11	144	145	129	17	27	56
12	134	114	187	22	20	58
13	130	152	87	24	19	57
14	148	100	125	17	14	69
15	121	122	131	9	25	66
16	131	166	143	12	17	71
17	135	98	93	16	21	63
18	135	153	215	23	33	44
19	150	128	97	8	18	74
20	135	94	149	28	25	47
21	146	112	106	26	27	47

Appendix H

IRB Approval Letter

FORT HAYS STATE UNIVERSITY

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OFFICE OF SCHOLARSHIP AND SPONSORED PROJECTS

DATE:	May 15, 2018
TO:	Jessica Johnson, BGS
FROM:	Fort Hays State University IRB
STUDY TITLE:	[1184161-2] The Influence of Pre- and Postdinner Exercise in Relation to Postprandial Blood Glucose Levels in Type 2 Diabetics
IRB REFERENCE #:	18-127
SUBMISSION TYPE:	Amendment/Modification
ACTION:	APPROVED
APPROVAL DATE:	May 15, 2018
EXPIRATION DATE:	May 14, 2019
REVIEW TYPE:	Administrative Review

Thank you for your submission of Amendment/Modification materials for this research study. Fort Hays State University IRB has APPROVED your submission. This approval is based on an appropriate risk/ benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Administrative Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form unless documentation of consent has been waived by the IRB. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document. The IRB-approved consent document must be used.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Leslie Paige at 785-628-4349 or lpaige@fhsu.edu. Please include your study title and reference number in all correspondence with this office.

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Thesis: The Influence of Pre- and Post Meal Exercise in Relation to Postprandial Blood Glucose Levels in Type II Diabetics

Author: Jessica Johnson

Signature: Jessica Johnson

Date: 4-12-19