2016

Effect of Carbohydrate Loading vs. Fasting on Blood Glucose Levels in a 400 Meter Sprint Performance

Matthias E. Reiber
Bowling Green State University

EFFECT OF CARBOHYDRATE LOADING VS. FASTING ON BLOOD GLUCOSE LEVELS IN A 400 METER SPRINT PERFORMANCE

Matthias E. Reiber

Master's Project

Submitted to the School of Human Movement, Sport, and Leisure Studies
Bowling Green State University

In partial fulfillment of the requirements for the degree of

MASTER OF EDUCATION
In
Sport Administration

Date April 20, 2016

Project Advisor

Matthew Kutz Ph.D. ______________________

Second Reader

Matt Laurent Ph.D. ______________________

Table of Contents

Abstract

Track and Field athletes need to fuel their bodies prior to workouts in order to have enough energy to consistently perform at a high level. Carbohydrate loading can have a positive impact in increasing endurance running capacity (Maffucci and McMurray 2000; Savvas and Karamanolis 2008; Galloway et al 2014). These studies include blood glucose testing surrounding exercise bouts lasting more than 30 minutes. The purposes of my study were to investigate how blood glucose reacts after a high intensity bout of sprinting in the anaerobic glycolytic metabolic state lasting no more than two minutes. Along with blood glucose, I was interested in seeing if sprint time, and Rate of Perceived Exertion (RPE) would change significantly between tests. I hypothesized that blood glucose levels would drop after a period of fasting, and that the result would cause further decrease in blood glucose after the second sprint test. It was also my hypothesis that there would be an increase in Rate of Perceived Exertion (RPE) between fasting groups compared to carbohydrate loading groups. Lastly, I hypothesized that the participants would run slower after fasting relative to baseline compared to those who partook in carbohydrate loading. 10 Bowling Green State University (BGSU) students participated in my study. All participants ran in two timed 400 meter sprints separated by 48 hours rest. Four participants carbohydrate loaded before the second test, while the other six participants fasted prior to the second test. A One-Way ANOVA with a washout period producing three groups (baseline n=10, fasting n=6, and carbohydrate loading n=6) was used to analyze the data. Results indicate that there is a significant rise in blood glucose three hours after carbohydrate loading, while fasting for more than eight hours decreased blood glucose levels significantly. This change did not show a significant relationship towards dependent

variables of post-exercise blood glucose, sprint time, or RPE change. Findings from this research project re-affirm that there is a significant change in blood glucose with a study design of fasting for more than eight hours, or carbohydrate loading three hours prior to the activity. Contrary to previous research in endurance running, this study design did not produce significant outcome changes on sprint performance.

Introduction

Competitive Track and Field athletes have a genetic predisposition paired with specific training regimes to account for success in competition (Maugan & Gleeson, 2004). These athletes range in all different body types, from a 110 pound female 10k distance athlete, to the 380 pound male shot put thrower. Each athlete trains in a specific metabolic system that is conducive to the demands of their events.

The body operates in three primary energy systems in order to sustain movements during exercises. These metabolic systems are: phosphocreatine, glycolytic, and oxidative. The phosphocreatine system accounts for the first 15 seconds of an activity. Adenosine triphosphate (ATP), which is the basic unit of energy necessary for muscle contractions, is the most immediate source of energy. Used ATP becomes Adenosine Diphosphate (ADP). The compound Creatine Phosphate (CP) helps to convert ADP back into ATP for further muscle contractions (Brooks et al., 2000). This system is important because, it provides immediate energy for explosive movements. It may take several minutes of rest to restore normal levels in order to produce the same forceful movements or quality contractions (Harbili, 2015). Events in Track and Field that operate within the phosphocreatine system typically include, throwing events, vertical and horizontal jumps, the pole vault, and short distance running events such as the 60 and 100 meter sprints. It becomes necessary to rest between such events because the quality contractions needed cannot be replicated without the proper stores of CP within the muscle (Maugan & Gleeson, 2004). This is why competitors have anywhere between one to five minutes between attempts during field events, depending on the event at hand. In repetitive explosive movements with limited rest time, or contractions lasting longer than 15 seconds, the utilization of glucose as the next source of energy becomes essential, this is called glycolysis.

Anaerobic (or fast) glycolysis uses glucose within the muscle cytoplasm, and glycogen within the muscles themselves. This energy system sustains explosive movements roughly from 15 seconds to two minutes. The term anaerobic means without oxygen (Brooks et al., 2000). During anaerobic glycolysis, the process of glucose breakdown into pyruvate and its conversion to lactate, causes an imbalance of hydrogen ions. The buildup of hydrogen ions, and subsequent decrease in pH, is theorized to create muscle pain and soreness felt during high intensity exercises within this 30 second to two minute window (Plowman & Smith, 2008). Towards the end of this anaerobic activity timeframe, the quality of the exercise will diminish, as the glucose in the cytoplasm, and muscle glycogen will begin to become depleted. Oxidative means for sustaining muscle contractions at a decreased intensity will take over during this conversion in the latter half of this two minute time frame. Muscle and liver glycogen provide a sustainable source of energy for moderately high intensity exercise lasting up to 30 minutes (Maugan & Gleeson, 2004).

For sustained energy utilization at a decreased exercise intensity, full oxidative capacity is theorized to take effect after 30 minutes of activity (Brooks et al., 2000). Aerobic metabolism (or slow glycolysis) refers to the body’s ability to use oxygen to breakdown glucose into ATP. Compared to anaerobic glycolysis, this process is more efficient in terms of ATP production, but the conversion takes more time. Furthermore, the efficiency of fat conversion to glucose with oxygen use, is most efficient due to the amount of stores in the body compared to glycogen. Longer duration track events, such as the 5k and 10k will primarily use muscle glycogen stores and oxidative fat metabolism for energy. Athletes who frequently train at a moderate to high-intensity for longer durations of time, will increase their adaptation to using fats as an energy source (Brooks et al., 2000).

Caloric intake should be comparable to energy expenditure, with an appropriate amount of carbohydrates to replenish depleted glycogen stores lost during training and competition (Cermak & Loon, 2013). Eating enough when traveling to a competition, and on the day of the competition can be difficult plan for many of these athletes. Meets are sometimes a long endeavor, with typical warmup times lasting between 30 minutes to one and a half hours depending on the event. For those competing in multiple events, it may be challenging to find the time to consume adequate amounts (and in the right form) of calories in order to maintain energy stores without stomach upset. Reduced glycogen levels, resulting in lower levels of blood glucose, can have a negative impact on exercise performance (Karamanolis & Tokmakidis, 2008; Maffucci & McMurray, 2000). Normal resting blood glucose levels are between 70-99mg/dl after an 8 hour fast. In general, when blood glucose levels fall below 60mg/dl the body becomes hypoglycemic. Hypoglycemia is a deficiency of sugar in the blood stream. Common symptoms of hypoglycemia may include: nausea, trembling, irritability, confusion and decreased cognitive ability, blurred vision, dizziness, headache, poor neuromuscular coordination, and fatigue (American Diabetes Association, 2015).

Resting blood glucose should be more elevated than fasting levels, but no more than 140mg/dl two hours post meal. After exercise, a person's blood glucose could be elevated due to the transport of necessary glucose to the working muscles (Adams, 2013). In activities lasting longer than 30 minutes at a reduced intensity (50% VO2max) there will be a gradual decrease in blood glucose levels (Brooks et al., 2000). This results in a spike in blood glucose levels during the onset of physical activity, and then a steady decline as glycogen stores are conserved and oxidative metabolism kicks in. Fasting more than six hours has been shown to decrease exercise intensity of exercise lasting between 30-40 minutes. Eating a high carbohydrate meal three hours prior to exercise, has been reported to increase running performance intensity and duration (Maffucci & McMurray, 2000). Some track and field events are long enough for energy transfer from glycogen stores to the more efficient. In aerobic oxidation, short distance sprints of 100 meters or less are not solely dependent on glycogen stores. There is however, a gap in the literature to show changes in performance with running in the 15 second to two minute's window. As stated before, there is a steady increase in blood glucose levels during the onset of exercise. The start of exercise is also when the body is in a glucose burning anaerobic state. Track and Field events that fall in this category are 200, 400, and 800 meter sprint events.

Therefore, the purpose of this study was to investigate how blood glucose reacts after a high intensity bout of running in the anaerobic glycolytic metabolic state. Along with blood glucose, I was interested in seeing if sprint performance time, and Rate of Perceived Exertion (RPE) would change significantly between tests. I hypothesized that blood glucose levels would drop after a period of fasting, and that the result would cause further decrease in blood glucose after the second sprint test. I hypothesized that there would be an increase in Rate of Perceived Exertion (RPE) between fasting groups compared to carbohydrate loading groups. Lastly, I hypothesized that on average, the participants would run slower after fasting compared to those who partook in carbohydrate loading.

Review of Literature

Maffucci and McMurray (2000) conducted a research study to examine the effects of meal timing on a high intensity treadmill test. Subjects in this study consisted of eight well trained women between 18-30 years of age, competing for college teams or training for triathlons. Treadmill tests were broken up into intervals, between short sprints, and jogging. The method for the treadmill test is described by the authors:

> Following each of the first five data collection periods (min 6, 11, 16, 21, 26), the treadmill speed was increased by 2 mph for 30s in order to induce a short period of sprinting. The short sprints were introduced to vary the intensity of exercise to more closely approximate training or team sports and to increase the use of carbohydrate stores. At the end of the 30 min of exercise, the grade of the treadmill was increased by 2.5% every 2 min until volitional fatigue (i.e., the subject is unable to keep running at the grade and chooses to stop) VO_2, RER, heart rate, and RPE were determined minute-by-minute during the incremental states (Maffucci and McMurray 2000).

Each subject participated in two trials separated by 48 hours. The first trial took place six hours after consuming a meal. The second trial took place after consuming a meal six hours prior to testing, and with the same meal eaten again three hours prior. Meals consisted of 60% carbohydrate, 20% fat, and 20% protein. The meal amounted to about 40kJ/kg of body weight, which converts to about 575 calories, based on the average weight of 60kg in the test subjects. Glucose, lactate, insulin, and cortisol levels were determined from blood collection one minute before and one minute after each trial.

Maffucci and McMurray (2000) reported that elevated levels of blood glucose from a pre-test/post-test collection. However, the difference in amount is insignificant between trials. Insulin levels decreased in both trials after exercise, and this was found to be significant with a greater decrease in the fasting trials compared to the loading trials. The authors hypothesize that reduced glucose uptake during exercise in the fasting trial could have led to a greater decrease in post exercise insulin level. Blood lactate levels rose significantly more in the three hour trial, with no significant change in cortisol levels between trials.

Respiration exchange ratio (RER), became a key component to this study design. RER averaged .05 units lower in the fasting trials compared to the carbohydrate loading trials. This shows that although carbohydrates were still a main source for energy, fats were more utilized during the six hour pre-feed trial as opposed to the three hour pre-feed trial. The women in this study showed performance increases by lasting nearly 30 seconds longer at the higher intensity towards the end of the test in the carbohydrate loading trial compared to the six hour fasting trial. This was determined to be significant with a p-value=.0001. A greater reliance on carbohydrates for energy, caused an increase in exercise duration at a higher intensity for trials with a three hour pre-participation meal. Reduced time to fatigue caused by six hours of fasting could be related to the body’s utilization of fats in times of reduced glycogen stores. This study suggests that carbohydrates help to increase exercise duration at a high intensity if timed properly within a diet plan three hours before performance needs.

In pre-exercise meal timing of three hours prior to a 90 minute treadmill run at 70% $V0_2$ max, glycemic indices of food plays a significant role in exercise metabolism. Investigators of glycemic index and the role on exercise performance (Tzai-Li Li et al 2004) found that there is a greater utilization of FFA during prolonged exercise when low glycemic index (LGI) foods were consumed pre-exercise. Consequently, when participants consumed high glycemic index (HGI) foods prior to exercise, FFA levels in the blood were seen at lower concentrations, and insulin levels were elevated. The authors hypothesize that increased blood insulin levels contributed to increased glucose uptake along with better carbohydrate oxidation. The research in this study is important because, it suggests that the glycemic index of food plays a role in how the body metabolizes food during exercise. HGI foods may be better for activities where glycogen is the primary energy source.

Karamanolis and Tokmakidis (2008) reported improvements in endurance capacity can be aided with the ingestion of glucose in liquid form 15 minutes prior to running. Eleven experienced runners participated in a treadmill test consisting of three continuous running stages. Five minutes of running at 60% of VO_2 max, 70% of VO_2 max for 45 minutes, and 80% of VO_2 max until exhaustion. Participants ran an average of 1.5 kilometers further when they ingested glucose pre-trial, compared to a placebo glucose trial. This amounted to a 12.8% longer duration of running between the two trials. Serum glucose levels were significantly elevated at rest in the glucose supplement group compared to the placebo group after 15 minutes of consumption prior to exercise. A significant rise in blood insulin level was seen in the supplement group after 15 minutes of ingestion prior to activity, compared to the placebo group. This study follows similar conclusions to afore mentioned studies, that circulating glucose provides additional stores of energy needed for prolonged exercise at high intensities.

Galloway, Lott, and Toulouse (2014) showed that there is an increase in exercise performance by way of pre-exercise supplementation of high glucose sports drinks. The study design consisted of a bike ergometer test, which is described by the authors,

> Briefly, the starting work load was calculated in respect to each subject's body mass (2.5W/kg) and increased by 50W after 150s and thereafter increased by 25W every 150s until volitional exhaustion (failure to sustain a cadence above 60 rpm). PPO was then calculated according to the formula: $PPO=W_{final}+((t/150)*25)$ where W_{final} is the final workload attained and t is the elapsed time achieved during the stage. 25 is a constant reflecting the load increase per stage (Galloway et al 2014).

Consumption of liquid glucose in a 6.4% solution 30 minutes before yielded significant increases in peak power output (PPO) on a cycle ergometer, compared to consumption 60 minutes prior to activity. Both conditions were matched against placebo trials. Under the same exercise conditions the participants also ingested carbohydrate solutions of 2% and 20%. There was a small increase in exercise performance in both of these trials, but significance was only reached during the 6.4% trial. The authors suggest further investigation into the reasoning behind exercise performance increases with the specific concentrations of carbohydrates in a liquid form. Commercially available sports drinks typically contain carbohydrate concentrations from 4-6% (i.e. Gatorade and Powerade).

Suzuki, Shimizu, Ota, Ryuzo, Kenji, Yoshifumi, and Keishoku (2015) examine the conditioning status of athletes and the efficiency of these athletes' metabolic systems within the realm of their training specificity. Two female athletes participated in this study. One a college tennis player, and the other a triathlete. Both participants wore a continuous blood glucose monitoring system, and ran at a similar pace around a track for five continuous hours. The athletes had access to food and fluids throughout the run. The athletes maintained their pace throughout the run, without any sudden decrease or increase in pace. Along with the glucose monitoring, there were timed blood draws one hour before running, one hour into the run, three hours into the run, and after five hours of running. Results indicated that the distance athlete was better equipped to utilize stored glucose than the Tennis player. Blood glucose dropped significantly in the Tennis athlete during the first three hours and slowly returned to baseline during the remainder of the run. The Triathlete showed an increase in blood glucose during the first hour, with a gradual decrease over the next four hours. This study suggests that by training in an endurance capacity, endurance runners are better equipped to save glycogen stores compared to an athlete who trains in intermittent sprinting.

Sandvei, Jeppesen, Støen, Litleskare, Johansen, Stensrud, and Jensen, (2012) conducted a study to find that insulin sensitivity is greater in adults conditioned in sprint interval training at a high intensity, compared to adults conditioned in continuous running at a moderate intensity. The authors conducted an eight week study on 23 healthy adults in an effort to find which group would improve on insulin sensitivity and cholesterol profile. The 23 participants were randomly assigned to either a sprint interval training (SIT) group, or a continuous moderate intensity training group (CT). Heart rate monitors were worn in order to train at optimal percentages of their estimated maximum heart rate. The CT group increased training time from 30 minutes to 60 minutes of continuous running over the course of the study, while maintaining 70-80% of maximum heart rate during the runs. The SIT group sprinted in an all-out effort for 30 seconds with three minutes rest between each set. The sets increased gradually from five in week one, to 10 sets in week eight. Each group trained three times per week with two days rest between each session. Low density lipoproteins decreased by about 9% in the SIT group, where high density lipoproteins remained unchanged. Low density lipoproteins and high density lipoproteins in the CT group did not change significantly after eight weeks of training. Insulin sensitivity improved significantly more in the SIT group compared to the CT group after the eight weeks.

This study imposes important information for physically active adults looking to reduce the risk of diabetes and cardiovascular disease, by changing their cholesterol profile. It also has important implications for training in specific metabolic ranges. Increasing insulin sensitivity may have an effect on blood glucose levels during training, and the body’s adaptation to using glycogen stores during anaerobic glycolysis. It cannot be inferred from this study design specifically, as muscle biopsies were not taken. However, it begs for further research into what the metabolic adaptations are during these exercises in comparison across a similar longitudinal study. I am curious to know if those who train in an anaerobic capacity, compared to those in an oxidative capacity change significantly in muscle glycogen count after each training session from beginning to the end of the study.

Therefore, the purpose of this study was to investigate blood glucose changes before and after exercise in an anaerobic glycolytic state of metabolism. Along with blood glucose, I was interested in seeing if sprint performance time, and Rate of Perceived Exertion (RPE) would change significantly between tests. I hypothesized that blood glucose levels would drop after a period of fasting, and that the result would cause further decrease in blood glucose after the second sprint test. I hypothesized that there would be an increase in Rate of Perceived Exertion (RPE) between fasting groups compared to carbohydrate loading groups. Lastly, I hypothesized that on average, the participants would run slower after fasting compared to those who partook in carbohydrate loading.

Conceptual Framework

Track and Field is a performance specific sport. Meaning, the performance itself directly creates the outcome of each event. Team sports such as football, soccer, and basketball, allow for some error. If a teammate does not perform well, then it may not negatively impact the outcome of the game. In Track and Field, excluding relay events, there is no room for error. A person's performance on meet day will dictate the distance thrown, the height or distance jumped, and the time it takes to cross the finish line. Training becomes impactful, as athletes need to peak for important meets. Training in specific physiological metabolic ranges becomes pertinent to induce bodily adaptations to the training, and thus adaptations to the event for competition. Proper nutrition needs to be considered when maximal output is warranted. As health care professionals, it is easy to talk about nutritional needs from a day-to-day standpoint during training. Relaying appropriate information about the total caloric consumption and necessary amounts of carbohydrates, proteins, and fats needed for recovery is fairly straight forward. This becomes easy for athletes to understand once this knowledge is passed on to them. How much do we truly know about exercise performance in a single bout of exercise?

Specifically, what nutritional requirements need to be met beforehand to give our athletes the best physiological predisposition to optimal performance?

From the literature we know that the body uses glucose as a primary source of energy during high intensity bouts of exercise (Cermak and Loon 2013; Karamanolis and Tokmakidis 2008; Maffucci and McMurray 2000; Adams 2013; Tzai-Li Li et al 2004; Galloway et al 2014; Suzuki et al 2015). Much of the literature draws these conclusions based on exercise lasting longer than two minutes. However, there is a gap in the literature to show physiological changes during high intensity exercise lasting less than two minutes in one single effort. Brooks et al. (2000) shows that anaerobic glycolysis exists within a 15 second to two minute window. Meaning, that glucose is the primary energy source and not CT, and not FFA.

Carbohydrate loading has been shown to be effective in increasing exercise time and intensity during longer exercise efforts at a moderately high intensity (Maffucci and McMurray 2000; Savvas and Karamanolis 2008; Galloway et al 2014). I assigned groups of participants to either a fasting, or a carbohydrate loading group. Fasting will take place after consuming a meal, and will last eight hours. Whereas, carbohydrate loading consisted of a meal 40kJ/kg of body weight. This design was proven effective in research conducted by Maffucci and McMurray (2000). In an attempt to further boost blood glucose levels, the carbohydrate loading consumed a liquid carbohydrate sports drink of 20 ounces (Gatorade) 15 minutes prior warmup for exercise testing. This follows the protocol outlined by Savvas and Karamanolis (2008).

Testing in my design were two timed 400 meter sprints separated by 48 hours of rest. The first 400 meter sprint was a baseline. The participants were randomly be assigned to two groups. Group A consumed a prepackaged meal three hours before the second test, along with the sports drink supplementation 15 minutes prior to warm up for testing. Group B had an overnight fast of no less than eight hours. Blood glucose was taken prior to warm-up and after the 400 meter test during both trials of each group. A rate of perceived exertion (RPE) was identified for the 400 meter test after both sprint tests in each group. A sufficient warmup and cool down was provided for all participants in the study prior to, and after testing trials.

Methods

Subjects

Convenience sampling was used due to time constraints with Graduate Assistantship job duties. All potential participants were contacted in person either in the Sebo Athletic Training center on the BGSU campus, or at the Perry Field House, also located on the BGSU campus. All participants completed a consent form and medical questionnaire approved by the Human Subjects Review Board of Bowling Green State University. No participants were excluded for the study based on medical reasons. 10 BGSU students participated in this study. Inclusion based on age was between 18 and 26. Participants were restricted to either trained distance athletes, or trained sprinters. Participants were randomly assigned to a carbohydrate loading group or…

Procedures

After completing paperwork, subjects were given three different meal options based on body weight. Calculation of meal size was based on 40kj/kg of body weight. For example: if an individual weighed exactly 60 kg, then they would be calculated to eat about

573 calories. Each subject meal was estimated within 50 calories of projected intake. Three different selections for main portion of meals were either Lunchables, Uncrustables, or Easy Mac (Macaroni and Cheese). From there subjects had the option of either a clementine or apple and crackers or yogurt. The remaining calorie allotment was provided by Chewy Bars and/or fruit snacks, depending on how many calories were left. For a couple larger individuals in the study, they had the choice of two main portion options.

Participants were asked to eat an average sized meal three hours prior to the first run trial. This consideration was left up to the interpretation of the participants, and no specific guidelines were given. Upon reporting to the Perry Field House Indoor Track (200 meter track) for the first trial a blood glucose measurement was taken on each participant. The process for this was done in the following order. An alcohol swab was used to clean the designated fingertip in preparation for blood draw. A standard lancing device was used to draw a drop of blood from the fingertip. A new needle was unpackaged in front of every participant prior to each finger prick. A OneTouch Ultra meter was used to analyze blood glucose results. Blood glucose measurements were read and reported in mg/dL units. Participants were then taken through a warm-up that took around 8-10 minutes to complete (see appendix). Participants were allowed to run in whatever clothing and shoes they deemed to be most appropriate. Several participants ran in racing flats or track spikes. Several of the participants chose to use staring blocks. Timing for the 400 meter dash was calculated by a stop watch. The start of the stop watch was initiated by the participant's movement, and stopped when the participant crossed the finish line. All participants ran individually in order to create a non-competitive environment. A 200 meter split (one full lap) was read out loud during the trial to give the participants an indication of their pace.

This was done to give consistency between laps, and between each trial. Participants were given encouragement during the last 100 meters. Phrases such as: “Let’s go!” “All out!” “Finish strong!” were used. After the 400 meter dash was finished and participants did a walking cool down, the post-test blood glucose measurement was taken. Post-post glucose measurement was done in the same fashion as the pre-test measurement. An RPE number was given by each participant in analysis of how difficult the 400 meter run was.

Participants were informed of their group assignments immediately after trial 1 testing. Those in the carbohydrate loading group (Group A) were given their meal with the instructions to consume the food provided three hours before there next run trial. Those in the fasting group (Group B) were told not to consume anything other than water within 8 hours of the next trial. Participants were scheduled to return to the track for the second trial in 2 days. During the recovery period between trials, participants were told they may participate in activity, as long as they did not deem it to be strenuous enough to negatively impact performance for the second trial. All participants in Group B elected to run in the morning between 7-8am. All Group A members returned for testing in the evening between 6-7pm.

The testing for the trial two was identical to trial one amongst all participants, with the exception of Group A individuals consuming a 20 ounce Gatorade. After drinking the Gatorade, Group A participants waited 15 minutes before beginning trial two procedures. All participants were thanked for their time and dedication after completion of the second trial.

Data Analysis

All data from the trials were imputed into an excel spreadsheet and then imported into SPSS 22.0 for statistical analysis. All 10 participant's trial one tests were used as a "baseline" (baseline, n=10), where a washout period of 48-hours between trials differentiated Group A (Carb. Loading, n=4), and Group B (Fasting, n=6). This made three different groups where a One-Way ANOVA was used to measure significance both between groups, and within groups separately across the dependent variables. Dependent variables were: Pre-test glucose (Pre_Glucose_1, n=10), Sprint time (Sprint_Time_1, n=10), Post-test glucose (Post_Glucose_1, n=10), and Rate of Perceived Exertion (RPE_1, n=10). A significance level of .05 was a priori set for all data analysis. A significant *F* value resulted in an LSD post hoc analysis.

Results

Demographic results included three females and seven males. Mean participant experience in track competition was 5.9 years. The lowest level of experience was one year, and the highest level of experience was 13 years. Six participants classified themselves as trained sprinters. Four participants classified themselves as conditioned distance runners. Participants were between the age of 18 and 26, with an average age of 21.

Table 1. Data

Test Subject	Group	Classification	Pre Glucose 1	Sprint Time 1	Post Glucose 1	RP 1	Pre Glucose 2	Sprint Time 2	Post Glucose 2	RPE 2
1	B	Sprinter	148	65.29	107	7	106	66.04	108	6
2	A	Sprinter	116	67.77	106	7	126	67.11	94	6
3	B	Distance	81	66.6	143	5	67	68.14	100	5
4	A	Sprinter	98	61.64	99	3	108	58.14	119	5
5	B	Distance	95	61.69	128	5	86	64.22	129	8
6	B	Distance	68	58.75	106	6	73	59.61	113	8
7	B	Sprinter	84	69.2	96	8	78	70.05	91	9
8	B	Distance	116	91.11	151	7	87	91.86	105	5
9	A	Sprinter	76	82.58	87	4	106	69.36	109	8
10	A	Sprinter	84	68.78	105	7	128	66.25	116	6

There was a statistically significant difference in pre-test glucose measurements between groups as determined by one-way ANOVA ($F_{(2,17)}$=3.641, p=.048). A LSD post-hoc test revealed that pre-trial blood glucose was statistically significantly lower after fasting (82.83±13.67, p=.015) compared to the pre-trial blood glucose after carbohydrate loading (117.00±11.60).

Table 2. Variable Means (Blood Glucose, Sprint Time, and RPE)

Group	N	Pre Glucose	Sprint Time 1	Post Glucose	RPE
Baseline	10	96.6±24.0	69.3±10.03	112.9±20.9	5.9±1.60
Carb. Loading	4	117.0±11.6	65.2±4.9	109.5±11.2	6.3±1.3
Fasting	6	82.8±13.6	70.0±11.3	107.7±12.9	6.8±1.7
Total	20	96.6±22.2	68.7±9.4	110±16.6	6.3±1.6

There were no statistically significant changes in post-trial glucose (p=.842), sprint time (p=.724), or RPE (p=.533) between groups.

Discussion

An uneven distribution of distance and sprint athletes between groups is a design flaw that needs to be taken into consideration for future research. This study design is best suited specifically for trained track athletes, where selection criteria should be subject to equal ability and training status of the athletes. Post-test blood glucose tended to increase for those participants who consider their running training to be more endurance based. For the participants who classified themselves as sprinters, post-test blood glucose stayed relatively the same, or in some instances decreased compared to pre-test analysis. Training status may alter blood kinetics during running, as found by Yoshio et al (2015). Based on the research presented in this article, an athlete who trains in short intermittent bursts of sprinting, may see drops in blood glucose during initial phases of exercise. An endurance athlete who trains without intermittent stoppage will have an increase in blood glucose at the onset of exercise. With this in mind, my study design may not be best suited for my intended research outcomes. The four participants that participated in carbohydrate loading were all considered to be sprinters. The six participants in the fasting group were a mix of participants, with some considered trained sprinters, and some considering themselves to be trained distance athletes. An even distribution of distance and sprint athletes across groups, or inclusion of only one type of training status of athletes, should be considered for future study design. Previous experience in running a 400 meter dash is also a big factor in the accuracy of participant running time. Those participants who were club track and field members had more consistent times between trials. The participants who do not often train on the track, and compete in track and field events, show less consistent times between both trials. Another limitation in this study is the participant pool.

Limitations

Only ten people participated in this study, paired with the fact that several of these participants have not run a timed 400 meter sprint in well over a year, shows that this may be a bad model for consistency. Lastly, future consideration to have all subjects participate in both fasting and carbohydrate loading groups may paint a more accurate picture to show how individuals react to both conditions.

Conclusion

This research topic presents some practical analysis into the metabolic kinetics of running. If this study design were done on more experienced track athletes who are all conditioned sprinters under the same exercise protocol, would we see further drops in blood glucose after multiple sprints? Sprint times did not significantly change in this study design, but it may be interesting to see if further blood glucose drop causes a decrease in performance. As an Athletic Trainer Certified for a Division 1 athletics department working with football and track and field athletes, I have witnessed athlete's inability to perform after not eating within several hours prior to exercise. This decrease in performance is visible and is interpreted as a result from not physiologically having enough glucose in order to sustain the intensity of activity for the duration required. A more practical approach to witness glycogen depletion and decrease in exercise performance might be better analyzed through repeated sprints during a practice setting where athletes are in a fasting state. If an athlete has multiple sprint events at a track meet, then it might be assumed that further drops in blood glucose could result in decreased performance. Of course these are in no way drawn upon factual evidence with objective measurements.

As a result, this study further solidifies that after fasting for only 8 hours there is an observable difference in blood glucose levels compared to measurements taken 3 hours after a heavy carbohydrate high-glycemic index meal. There is no statistical evidence from this study to support that carbohydrate loading, or fasting will significantly change sprint performance time, RPE, or post-test blood glucose after a 400 meter sprint.

References

Adams, O. P. (2013). The impact of brief high-intensity exercise on blood glucose levels. *Diabetes, Metabolic Syndrome And Obesity: Targets And Therapy*, *6*113-122. doi:10.2147/DMSO.S29222

Brooks, G. A., Fahey, T. D., White, T. P., & Baldwin, K. M. (2000). *Exercise Physiology: Human Bioenergetics and Its Applications* (third ed.). Mountain View, CA: Mayfield Publishing Company.

Cermak, N., & Loon, L. (2013). The Use of Carbohydrates During Exercise as an Ergogenic Aid. *Sports Medicine*, *43*(11), 1139-1155.

Harbili, S. (2015). The Effect of Different Recovery Duration on Repeated Anaerobic Performance in Elite Cyclists. *Journal Of Human Kinetics*, *49*(1), 171-178.

Hypoglycemia (Low Blood Glucose) (2015, July 1). In American Diabetes Association. Retrieved from http://www.diabetes.org/living-with-diabetes/treatment-and-care/blood-glucose-control/hypoglycemia-low-blood.html

Karamanolis, I. A., & Tokmakidis, S. P. (2008). Effects of carbohydrate ingestion 15 min before exercise on endurance running capacity. *Applied Physiology, Nutrition & Metabolism*, *33*(3), 441-449.

Maffucci, D. M., & McMurray, R. G. (2000). Towards Optimizing the Timing of the Pre-Exercise Meal. *International Journal Of Sport Nutrition & Exercise Metabolism*, *10*(2), 103.

Maughan, R., & Gleeson, M. (2004). *The Biochemical Basis of Sports Performance*. Oxford, NY: Oxford University Press.

Plowman, S. A., & Smith, D. L. (2008). *Exercise Physiology for Health, Fitness, and Performance* (second ed., pp. 104-107). Philadelphia, PA: Lippincott Williams & Wilkins.

R. Galloway, S. D., E. Lott, M. J., & Toulouse, L. C. (2014). Preexercise Carbohydrate Feeding and High-Intensity Exercise Capacity: Effects of Timing of Intake and Carbohydrate Concentration. *International Journal Of Sport Nutrition & Exercise Metabolism*, *24*(3), 258-266.

Sandvei, M., Jeppesen, P. B., Støen, L., Litleskare, S., Johansen, E., Stensrud, T., & ... Jensen, J. (2012). Sprint interval running increases insulin sensitivity in young healthy subjects. *Archives Of Physiology And Biochemistry, 118(3), 139-147. doi:10.3109/13813455.2012.677454*

Suzuki, Y., Shimizu, T., Ota, M., Ryuzo, H., Kenji, S., Yoshifumi, T., & ... Keishoku, S. (2015). Different training status may alter the continuous blood glucose kinetics in self-paced endurance running. *Experimental & Therapeutic Medicine*, *10*(3), 978-982. doi:10.3892/etm.2015.2587

Tzai-Li, L., Ching-Ling, W., Gleeson, M., & Williams, C. (2004). The Effects of Pre-Exercise High Carbohydrate Meals With Different Glycemic Indices on Blood Leukocyte Redistribution, IL-6, and Hormonal Responses During a Subsequent Prolonged Exercise. *International Journal Of Sport Nutrition & Exercise Metabolism, 14(6), 647-656.*

Appendix

Informed Consent for
<u>Effect of Carbohydrate Loading vs. Fasting on Blood Glucose Levels in a 400 Meter Sprint Performance</u>

Introduction: Hello, my name is Matthias Reiber and I am a Graduate Assistant Athletic Trainer with the Football and Track and Field teams here at Bowling Green State University. I am currently working on my Master's degree in Sports Administration from the School of Human Movement, Sport, & Leisure Studies. My advisor for my Master's program is Dr. Matthew Kutz. My research topic is on the <u>Effect of Carbohydrate Loading vs. Fasting on Blood Glucose Levels in a 400 Meter Sprint Performance.</u>
I am searching for Bowling Green State University College students between the ages of 18-26 with former high school track experience. Candidates for this project must be active runners who feel they are in condition to perform a 400 meter sprint around a standard outdoor track. Ideal candidates are, BGSU varsity or club sport athletes where sprinting is required in their sport.

Purpose: Intent is to find if blood sugar levels (high or low) have any effect on a 400 meter sprint timed performance. Benefits for this study are geared towards finding a pre-competition nutrition plan for middle distance sprint athletes. Participants who are involved in sports will be given results of this study, in an effort to help understand their own needs for meal timing before competition. There is no monetary benefit or school related reward for participating in this study.

Procedure: Participants will sign their name, age, track years of experience, telephone number, and email on a sign-up sheet. Contact will begin via participant's preferred contact method to set up times for pre-participation paperwork. Once all paperwork has been provided, explained, and signed the participant will be enrolled in the study. Paperwork is estimated to take 30 minutes. 3 hours prior to the first timed 400 meter sprint test, participants will be asked to eat what they would consider to be an average well balanced meal. Upon showing up for the first sprint test the participant will have a drop of blood drawn from a lancing device for a blood glucose test. A new lancing needle will be unpackaged in front of the subject for every single blood draw. Blood glucose will be calculated on a standard ReliOn Ultima blood glucose monitor. Prior to performing the 400 meter sprint, participants will be taken through a dynamic 8-10 minute warm-up. Then the participant will perform a timed 400 meter sprint. A 400 meter cool down jog will follow the sprint test, and then a Rate of Perceived Exertion scale number will be given by the participant in regards to how hard the test was. Blood glucose will be assessed again through the same method as previously mentioned. The participant will be informed at that time if they are in group 1 or group 2. Group 1 will eat a carbohydrate loaded meal 3 hours prior to the next run test. This meal will be provided by myself and will include 3 meal options. Each food item will be individually wrapped with Food and Drug Administration label attached. Group 2 will fast for no less than 8 hours, and may only consume water during this timeframe. This group will be asked to perform the second sprint test in the morning so that they can fast overnight. Participants will be asked to not perform any high intensity workouts over the next 48 hours until the second test. Roughly 48 hours after the first test the participant will return to the track for the second test trial. Blood glucose collection, warm-up, test, cool down, and Rate of Perceived Exertion scale measurement will be the same for the second test as the first test. Group 1 members will be given a 12 oz Gatorade 15 minutes prior to warm-up to help boost blood glucose content. Total time committed to each test day for both Group 1 and Group 2 will be between 20-25 minutes.

Voluntary Nature: Your participation is completely voluntary. Selection for this research will be based on the criteria mentioned in the introductory paragraph. You may decide to skip questions (or not do a particular task) or discontinue participation at any time during research. If there are any changes in health that you feel will limit you in the study, or may exacerbate conditions, then you should let the administrator know. Deciding to participate or not will not affect your (grades/class standing) or you relationship with (Bowling Green State University, your teacher, your school, your coaches, your job…any institution involved in the research). You will have a say in when the research is conducted. No time commitments in this research will interfere with academic, or athletic participation.

Confidentiality/Anonymity Protection: Trials for each individual will be recorded on individual sheets. These documents will be kept in a lock box at my house along with any other papers including participant name (medical questionnaire, sign-up sheet.) Computer data will contain numbers in place of participant names in order to keep confidentiality. Computer data will be recorded on my personal laptop, and only I will have the login to access this information. The final report will not contain any identifying factors to keep participant information anonymous. Final records will be reviewed by my advisor (Dr. Matthew Kutz) in order to develop information into my Master's project submission. Upon completion of my Master's Project, all computer based information will be transferred into paper format and kept in the lockbox previously mentioned in this paragraph. This information will be stored for 3 years, as required by institutional policy.

Risks: Stress from increased heart rate and blood pressure during exercise may be a risk for anyone with cardiovascular disorders/diseases. In order to reduce this risk, each participant must fill out a medical history questionnaire. Please note, that this questionnaire is in an effort to include only individuals healthy enough for this data collection. I will be present during the time this questionnaire is filled out, and can field any questions at that time. After filling out the medical questionnaire, I will be able to review your risk factors and determine if you are eligible for the study. If I am unsure of the risk factors indicated by your responses, I will ask for your permission to have my advisor Dr. Matthew Kutz review your medical history form. In the case where review is required, I will contact you via your preferred contact method to notify you of your eligibility, or disqualification for the study. An Automated External Defibrillator will be on-site for the study trials. I am trained as an Athletic Trainer in Cardio Pulmonary Resuscitation/Automated External Defibrillation administration. Participants will be subject to a proper dynamic warm-up 8-10 minutes in length in an effort to decrease risk for injury. Injury sustained through participation that requires medical attention will need to be paid for by the participant in the study.

Contact information: Please do not hesitate to contact me at any point in time with questions in regards to this project. My phone number is (785) 764-8932, and my email address is mreiber@bgsu.edu. My advisor, Dr. Matthew Kutz may be reached at (419) 372-5917 or by email, mkutz@bgsu.edu. You may also contact the Chair, Human Subjects Review Board at (419) 372-7716 or hsrb@bgsu.edu, if you have any questions about your rights as a participant in this research. Thank you very much for your time.

I have been informed of the purposes, procedures, risks and benefits of this study. I have had the opportunity to have all my questions answered and I have been informed that my participation is completely voluntary. I agree to participate in this research.

____

Participant Signature

PREVIOUS HISTORY AND VITALS

Name: ______ Date of Birth: ______ Sex: M F

Sport: ______ Class: Frosh Soph JR SR 5th YR

Campus Address: ______

Cell Phone: ______ Email Address: ______

Emergency Contact: ______ Emergency Phone: ______

Physician's Name/Address/Phone #:

MEDICAL HISTORY	Y	N
1. Has a doctor ever denied or restricted your participation in sports for any reason?	☐	☐
2. Were you born without or have you suffered the loss of a lung, kidney, eye, testicle, ovary, or any other organ?	☐	☐
3. Has a doctor ever told you that you have : (Circle, if yes) High Blood Pressure Heart Murmur Heart Problem High Cholesterol Heart Infection	☐	☐
4. Have you ever passed out or nearly passed out **during** exercise?	☐	☐
5. Have you ever passed out or nearly passed out **after** exercise?	☐	☐
6. Have you ever had discomfort, pain, or pressure in your chest during exercise?	☐	☐
7. Does your heart race or skip beats during exercise?	☐	☐
8. Do you tire more quickly than your teammates?	☐	☐
9. Has a doctor ever treated you for asthma or seasonal allergies?	☐	☐
10. Do you cough, wheeze, or have difficulty breathing during or after exercise?	☐	☐
11. When exercising in the heat, have you had severe muscle cramping?	☐	☐
12. Have you ever become ill from exercising in the heat?	☐	☐
13. Have you ever been told you have Sickle Cell Anemia or Trait?	☐	☐
DO YOU HAVE OR HAVE YOU EVER HAD:	**Y**	**N**
14. Pneumonia?	☐	☐
15. Mononucleosis?	☐	☐
16. Rheumatic Fever or Scarlet Fever?	☐	☐
17. Diabetes?	☐	☐
18. Epilepsy/ Convulsions/ Seizures?	☐	☐
19. Any bleeding problems or Anemia?	☐	☐
20. An immune system disease?	☐	☐
21. Kidney Disease?	☐	☐
22. A hernia?	☐	☐
23. A stomach disorder or appendicitis?	☐	☐
24. Recurrent headaches?	☐	☐
25. Abdominal pain or nausea?	☐	☐
26. Been hospitalized?	☐	☐
27. Any surgeries?	☐	☐
28. A stress fracture?	☐	☐
29. A screw, pin or plate surgically implanted into your body?	☐	☐
30.	☐	☐
31. Are you taking **ANY** supplements, vitamins or herbs?	☐	☐
32. An allergic reaction to medication, food or insects?	☐	☐
33.	☐	☐
34.	☐	☐
35.		
36.		
37.		
38.		

39.		
40.		
41.		
42.		
43.		
44.		
FAMILY HISTORY	**Y**	**N**
45. Family history of Heart conditions?	☐	☐
46. Family history of High blood pressure?	☐	☐
47. Family history of Sickle cell anemia or trait?	☐	☐
48. Family history of Dying during or following exercise?	☐	☐
49. Family history of Death prior to the age of 50?	☐	☐
50. Family history of Asthma?	☐	☐
51. Family history of Marfan's syndrome?	☐	☐
52. Family history of Eating disorders?	☐	☐
53.	☐	☐
	Y	**N**
54.		
55.		
56.		
57.	☐	☐
GENERAL QUESTIONS	**Y**	**N**
58. Have you been wearing any type of brace, support, or other special padding for participation in athletic activities?	☐	☐
59. Have you had an illness or injury in the last 12 months that has not been listed previously?	☐	☐
60. Have you used in the past or are you currently using any type of performance enhancing substances or drugs?	☐	☐
61. Are you currently taking medication for Attention-Deficit Hyperactive Disorder?	☐	☐
62. Do you know of any health reason why you should not participate in this study at this time?	☐	☐
63. Have you ever been prescribed an inhaler or currently use one?	☐	☐

EXPLAIN ALL "YES" ANSWERS TO THE ABOVE QUESTIONS IN THIS SPACE REFERRING TO THE QUESTIONS BY THEIR NUMBER:	
#	
#	
#	
#	
#	
#	
#	
#	
#	
#	

HAVE YOU HAD AN INJURY OF:	Yes	No	Side		Date	Current Problem?	
64. **HEAD** (concussion- 'knocked out', surgery, hospitalization, other)	☐	☐	LT	RT		Yes	No
65.	☐	☐	LT	RT		Yes	No
66.	☐	☐	LT	RT		Yes	No
67.	☐	☐	LT	RT		Yes	No
68.	☐	☐	LT	RT		Yes	No
69.	☐	☐	LT	RT		Yes	No
70.	☐	☐	LT	RT		Yes	No
71. **CHEST** (pain, lungs, heart, surgery, other)	☐	☐	LT	RT		Yes	No
72. **ABDOMEN** (kidney, spleen, appendix, liver, surgery, other)	☐	☐	LT	RT		Yes	No
73.	☐	☐	LT	RT		Yes	No
74. **BACK** (strain, sprain, fracture, chronic pain, disc, surgery, other)	☐	☐	LT	RT		Yes	No
75. **HIP/THIGH** (strain, fracture, surgery, other)	☐	☐	LT	RT		Yes	No
76. **KNEE** (sprain, cartilage, bursitis, tendonitis, patella, surgery, other)	☐	☐	LT	RT		Yes	No
77. **LOWER LEG** (sprain, strain, fracture, tendonitis, shins, surgery, other)	☐	☐	LT	RT		Yes	No
78. **ANKLE** (sprain, strain, fracture, tendonitis, surgery, other)	☐	☐	LT	RT		Yes	No
79. **FOOT** (sprain, fracture, strain, tendonitis, surgery, other)	☐	☐	LT	RT		Yes	No
80. **TOES** (sprain, fracture, surgery, other)	☐	☐	LT	RT		Yes	No
81. **OTHERS:**	☐	☐	LT	RT		Yes	No

EXPLAIN ALL "YES" ANSWERS TO THE ABOVE QUESTIONS (#64-81):	
#	
#	
#	
#	
#	
#	

DIET HISTORY

DO YOU HAVE or HAVE YOU EVER HAD:	Yes	No	Date	Explain
82.	☐	☐		
83.	☐	☐		
84.	☐	☐		
85.	☐	☐		
86. Are you currently taking any vitamins, minerals, or supplements?	☐	☐		
87. Are there any food groups you choose not to eat (meat, dairy, etc.)?	☐	☐		
88.				
89. What Foods, including supplements, have you eaten in the last 24 hours?				
Breakfast:				
Lunch:				
Dinner:				
Snacks				

THE UNDERSIGNED PARTICIPANT:

1. Understands that this document may be reviewed by a physician, to determine if medical qualifications are met in order to proceed with trials in this study.
2. Certifies that the answers to the above questions are correct and true to the best of his/her knowledge.

PARTICIPANT'S SIGNATURE: ______________________________ DATE: ______________________

I have reviewed this history with the participant, and answered all questions.

PROJECT ADMINISTRATOR SIGNATURE: ______________________________ DATE: ______________________

VITALS

Height: ________________ Weight: __________________ SpO2: ________

Pulse: __________ BP: Left arm _____/_____ Right Arm _______/_______

(PRN BP Recheck or position) Left arm _____/_____ Right Arm _______/_______

Warm-up protocol

Jog 1-2 laps

15 meter increments

- A-Skip
- B-Skip
- AC-Skip
- Butt Kicks
- Karaoke (down and back)
- Walking Lunges
- Open The Gate
- Close The Gate
- Walking Tin-Man

Self-stretch as needed

Cool-down consists of walk or jog 1 lap (200m)

Trial Sheet

Name:									
Trial 1									
	Date			Time					
	Meal discription:								
	Pre-glucose		mmol/L						
	Sprint time								
	Post-glucose		mmol/L						
	RPE								
Trial 2									
	Date			Time					
	Group #								
	Meal option:		Fasting	1	2	3	Gatorade		
	Pre-glucose		mmol/L						
	Sprint time								
	Post-glucose		mmol/L						
	RPE								