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Effect of Honey on Anaerobic Performance in Male Collegiate Soccer Players

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EFFECT OF HONEY ON ANAEROBIC PERFORMANCE IN MALE COLLEGIATE SOCCER PLAYERS

by

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Under the Direction of Amy Jo Riggs

ABSTRACT

Carbohydrate supplementation has been associated with increased performance in aerobic and anaerobic activity. Honey, specifically, has shown to increase performance in aerobic exercise as well as provide other health benefits. The purpose of this study was to see if honey, a natural substance, has a positive effect on anaerobic performance, rates of perceived exertion, and gastrointestinal distress. Subjects consisted of 18 healthy, Division 1 collegiate male soccer players (19.39 ± 0.85 yr, 75.39 ± 7.97 kg). All had no allergies and were cleared for participation by a certified athletic trainer. Subjects were randomly assigned to one of three groups. Each group tested on a specific day of the week for three weeks. After consuming the same meal the night before, adhering to a 10 hour fast, and 10 hour refrain from exercise before testing, they reported to practice and blindly ingested one of three different supplements (9.5oz. of flavored water, 9.5oz. of PowerAde, and 1 Tablespoon of honey mixed with 3oz. of water). They were given a different supplement each week in a random order based on their group assignment. Immediately after ingestion, they were given 15 minutes to complete the team warm up and prepare to run a repeated anaerobic sprint test (RAST). Subjects then ran the RAST and times were recorded and analyzed looking at maximum, minimum, and mean power, and fatigue index. Immediately following the RAST, subjects answered questions about gastrointestinal distress, and rated their perceived exertion. Pre-test carbohydrate ingestion showed no significant effect on maximum, minimum, or mean power, fatigue index, or rate of perceived exertion ($p>0.05$) for any of the three supplements. Some subjects experienced gastrointestinal distress, but side effects were minimal under all supplements. This study found that the ingestion of honey before an anaerobic performance test does not improve performance. However, it also did not cause any detrimental side effects to decrease performance. Because carbohydrate supplementation has been shown to improve performance and neither of the supplements improved performance over the placebo, further research needs to be done.

INDEX WORDS: Honey, Anaerobic performance, Repeated anaerobic sprint test, Rate of perceived exertion, Gastrointestinal distress, Maximum power, Minimum power, Mean power, Fatigue index.

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DEDICATION

This thesis is dedicated to my mother, Emily. Thank you for the idea, lending an ear, and all of your support along the way. It has been eye-opening for all of us and I couldn't have done it without you. I love you!

Special thanks to my father, David and my brother Michael, for assisting, pushing me, and helping me laugh when I needed it most. I love you!

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CHAPTER 1

INTRODUCTION

Purpose of the Study

Using pre- or peri-workout supplements has become progressively more popular among recreational and elite athletes. Most of this stems from studies that suggest that aerobic and anaerobic performance can be improved with the ingestion of supplements and recommendations from expert panels in sports nutrition (Schmitz, Hofheins, & Lemieux, 2010). Athletes use dietary supplements with the assumption that their performance will improve. However, supplements are often used without a full understanding of the potential benefits and/or risks (Maughan, Depiesse, & Geyer, 2007). Therefore, it is important for athletes to understand what is in a supplement, how it works, and how it may affect health and performance.

When a person exercises at a high intensity or for long periods of time, glycogen stores are depleted and need to be replenished. Ingesting carbohydrates can improve one's performance by maintaining blood glucose levels and sparing liver glycogen (Campbell, Prince, Braun, Applegate, & Casazza, 2008). Past research on carbohydrate ingestion focused primarily on its effects on aerobic capacity. Because carbohydrate oxidation increases between 75-90 minutes of exercise, it is imperative that athletes practice carbohydrate intake to achieve maximal performance (Earniest et al., 2004). During exercise, athletes want to limit the use of muscle and liver glycogen as a source of energy. By preserving liver glycogen, an athlete can exercise harder and longer. Ingesting carbohydrates while exercising can reduce and replace hepatic glucose production, which is the sparing of liver glycogen (Wallis, Dawson, Achten, Webber, & Jeukendrup, 2006).

What becomes important is the timing, type of carbohydrate, and amount that one ingests. This is because the glycemic index of a product can promote glucose and insulin response for athletes in regards to glycogen storage and/or anabolic responses to exercise (Kreider et al., 2007). Currell and Jeukendrup (2008) investigated the effect of different gels on endurance performance. When comparing glucose, to a glucose and fructose mixture, or plain water with trained cyclists, results revealed that a glucose and fructose mixture produced an 8% quicker time to completion when compared to strictly glucose or water. Because fructose has a more moderate glycemic index, a gradual increase in blood glucose over time may occur rather than a quicker spike. In addition, the glucose-fructose mixture led to sparing of endogenous carbohydrate stores, probably due to fructose having a more moderate glycemic index compared to glucose.

Honey has a high concentration of carbohydrates, but depending on its source, can have a relatively low glycemic index, making it an excellent source of energy for athletes (Bogdanov, Jurendic, Sieber, & Gallman, 2008). The composition of honey is mostly fructose and glucose, two monosaccharides, making honey extremely easy to digest and absorb. Because honey gives the body a quick source of energy, it has been used for aerobic exercise such as long distance running and cycling. In addition to being used for energy, honey has been used for nutritional and medical purposes for centuries. King Solomon states in the Bible, "Eat honey my son, because it is good." (Proverbs 24:13). Apitherapy, an alternative medicine branch, is where people treat diseases with honey and other bee products (Bogdanov et al., 2008). Most common medical uses for honey deal with topical application for wounds, burns, and infections. People have also used honey to treat allergies, sore throats, and skin. It is often used to replace table sugar as a sweetener in foods and beverages. Research has found that honey can significantly lower glucose levels, C-reactive protein, and blood lipids when compared to glucose and sucrose in healthy, diabetic, and hyperlipidemic subjects (Cortes, Vigil, & Montenegro, 2011).

For athletes, supplementation seems to be a simple way of improving one's performance, but supplementation doesn't always come without side effects. Often times, synthetic supplements are used and although some may improve energy levels or support weight loss, they may also cause psychiatric, autonomic, or gastrointestinal symptoms and lead to heart palpitations (Kreider et al., 2010). Athletes should be wary of the substances they use to improve performance. Following a well-balanced diet and healthy lifestyle may be enough to reach optimal performance. Carbohydrates, lipids, and amino acids are sources of energy, that when used correctly can be beneficial in improving performance. However, there is controversy regarding use during anaerobic activity. Some researchers question whether improvements seen under these circumstances are caused by a placebo effect (Earniest et al., 2004). More research needs to be done in order to determine if improvement of anaerobic performance due to carbohydrate consumption is physical, psychological, or a combination of both.

Purpose Statement

Because past research has shown that simple carbohydrates positively affect aerobic endurance performance, the purpose of this study was to determine whether honey, a low glycemic sugar, will 1) have a positive effect on anaerobic performance in collegiate level male soccer players, 2) have varying results on perceived exertion, and 3) have varying effects on gastrointestinal symptoms.

Hypotheses

The findings of this study will support the assertion that 1) the participants' scores for anaerobic maximum power output during the RAST will be significantly better with the honey and sports drink trials when compared to the placebo trial, 2) the participants' scores for anaerobic minimum power output during the RAST will be significantly better with the honey and sports drink trials when compared to the placebo, 3) the participants' scores for anaerobic mean power output during the RAST will be significantly better with the honey and sports drink trials when compared to the placebo trial, 4) the participants' fatigue index during the RAST will be significantly better with the honey and sports drink trials when compared to the placebo trial, and 5) The RPE scores of the honey and sports drink trials will decrease compared to the placebo trial.

It also will support the statements 1) the participants' scores for anaerobic maximum power output on the RAST for the honey trial will be equal to or better when compared to the sports drink trial, 2) the participants' scores for anaerobic minimum power output on the RAST for the honey trial will be equal to or better when compared to the sports drink trial, 3) the participants' scores for anaerobic average power on the RAST for the honey trial will be equal to or better when compared to the sports drink trial, 4) the participants' fatigue index on the RAST for the honey trial will be equal to or better when compared to the sports drink trial, and 5) the RPE scores of the honey trial will decrease equally or better when compared to the sports drink trial.

In addition, the research question: "Does ingestion of honey cause gastrointestinal distress before or during an intense bout of anaerobic activity?" will be addressed.

Rationale

Past research has shown that supplementation of carbohydrates improves performance in endurance exercise, but there is conflicting evidence regarding resistance exercise and anaerobic testing (Campbell et al., 2008; Earniest et al., 2004; Wallis et al., 2006; Kreider et al, 2007).

Supplementation may cause adverse side effects, especially synthetic supplements (Maughan et al., 2007; Kreider et al., 2010). Therefore, using natural supplementation such as honey may be beneficial in improving sport performance while alleviating possible negative side effects seen with synthetic supplements. In addition, honey has been shown to provide health benefits, such as lowering glucose levels, C-reactive protein, and blood lipids levels, as well as helping with allergies, sore throats and skin integrity (Bogdanov et al., 2008; Cortes et al., 2011). This study will seek to determine whether honey is an appropriate carbohydrate to improve anaerobic performance in collegiate male soccer players.

Limitations

Because this study was limited to the members of the Georgia Southern University Men's Soccer Team, the results may not be generalized to other populations. Also, certain players may have existing injuries, or injuries that arise during the testing period, hindering their performance. Subjects may not be compliant to the diet protocol the night before testing day. Lastly, subjects may not have fasted and avoided exercise 10 hours prior to their assigned testing day.

CHAPTER 2

EFFECT OF HONEY ON ANAEROBIC PERFORMANCE IN MALE COLLEGIATE SOCCER PLAYERS

Honey: Composition, Uses, Benefits

Honey is a form of carbohydrate used in a wide variety of assorted products. Sources, dating back to 2100-2000 BC, reference honey as being used not only as a food product, but also as an ointment and for medicinal purposes (Bogdanov, Jurendic, Sieber, & Gallmann, 2008). Today, honey is used as a sweetener for all types of foods in addition to providing an alternative treatment option for allergies in some people. Honey also contains many other constituents that provide a nutritional and biological benefit, such as antioxidant, antiviral, anti-inflammatory, anticancer and immunosuppressive activities, making it a valuable and nutritional addition to an individual's diet. (Bogdanov et al., 2008).

Honey prevents growth of micro-organisms and fungi, such as *Rubella* in vitro, three species of *Leishmania* parasite, and *Echinococcus*. It also has antioxidant capabilities. Because it contains glucose oxidase, catalase, ascorbic acid, phenolic acids, polyphenols, organic acids, amino acids, and proteins, honey has been found to have significant antioxidant activity (Bogdanov et al., 2008). One study researching the antioxidant capabilities of honey, compared treatments of buckwheat honey and corn syrup (1.5g/kg of body weight for both). Results revealed that total plasma total-phenolic content increased along with plasma antioxidant and reducing capabilities in those that consumed honey. Therefore, phenolic antioxidants from processed honey are bioavailable and can increase antioxidant activity of plasma (Schramm et al., 2003).

With regards to anti-inflammatory benefits from honey, Al-Waili & Boni (2003) analyzed subjects' plasma concentrations for inflammatory markers, including prostaglandin E(2) (PGE(2)), PGF(2alpha), and thromboxane B(2). Subjects' blood was taken and then required to drink 250 mL of water containing 1.2g/kg of body weight of natural unprocessed honey. Blood was then collected every hour for three hours following honey ingestion. Subjects were then asked to ingest the same amount of honey/water for 15 days. On the 16th day, blood tests were repeated. Levels of thromboxane B(2), PGE(2), and PGF(2a) all decreased by 48%, 63%, and 50%, respectively (Al-Waili, & Boni, 2003). These findings could be due to the antibacterial effect of honey or to a direct anti-inflammatory effect. Natural honey may contain nitric oxide metabolites, leading to a protective role in cardiovascular diseases (Bogdanov et al., 2008). In a study conducted by Heiss et al. (2006), nitric oxide related metabolites were measured in patients with endothelial dysfunction and found to be markedly reduced. There was also a correlation between the severity of endothelial dysfunction and decreased nitric oxide metabolites. Therefore, an increase in nitric oxide metabolites can improve endothelial function and protect against cardiovascular disease (Lundberg, 2006).

Glycemic Index

The advantages of honey do not just end with the aforementioned health benefits as honey is also used as an energy source. There are many types of honey, but most have been classified as having a low glycemic index. Glycemic index (GI) is defined as the glycemic effect of available carbohydrate in food relative to the effect of an equal amount of glucose (Monro & Shaw, 2008). Therefore, GI represents how a certain carbohydrate will affect one's blood glucose levels. Since honey is considered a low glycemic food, it will have a more gradual effect on blood glucose levels. This is because foods with a low glycemic index are hydrolyzed and absorbed slower than foods with high or moderate glycemic index. Examples of other low glycemic foods include: wheat, barley, grapefruit, yogurt, and bananas (Sport nutrition for health and performance, p. 27-29). Although honey is composed of mainly the same things, honey that comes from different sources may have different glycemic indices. For example, acacia honey from Romania has a GI of 32, whereas pure Australian honey has a GI of 58. Some commercial honeys can have a GI of up to 72 (Bogdanov et al., 2008).

Effect of Carbohydrate Ingestion on Aerobic Exercise

Benefits of carbohydrate ingestion related to aerobic activities have been well documented over the years. Improvement in performance for endurance exercise has become generally accepted since the 1920s because carbohydrate oxidation increases in exercise of longer duration, which is considered aerobic (Currell & Jeukendrup, 2008). As a result, aerobic athletes should practice carbohydrate intake to achieve maximal performance (Earnest et al., 2004). Carbohydrate ingestion has an ergogenic effect on athletes' performance. This occurs by plasma glucose concentrations being maintained as well as, allowing the body to spare glycogen stores. By maintaining blood glucose levels and sparing glycogen stores, athletes can access energy quicker and more consistently (Pfeiffer, Stellingwerff, Zaltas, & Jeukendrup, 2010).

Nutrients and water are absorbed scarcely in the stomach, and must enter the small intestine for absorption. Unlike water, which is absorbed promptly in the small intestine, nutrients such as glucose, fructose, and sodium are absorbed at different rates. Gastric emptying, the rate at which substances are released from the stomach into the duodenum, becomes an important limiting factor in absorption. It also determines what benefits one will receive from drinking a particular beverage. A fluid or sport drink taken to enhance performance should empty rapidly from the stomach, allowing for quicker absorption and fluid retention (Sport nutrition for health and performance, p. 233).

Currell and Jeukendrup (2008) studied the effect of different carbohydrate gels on endurance performance. Using eight trained male cyclists, researchers tested a glucose only beverage, a glucose and fructose beverage, and water, as a placebo. Each subject ingested one of the three beverages in random order. They were then required to complete a 120 minute cycling exercise followed by a time trial where subjects had to complete a specific amount of work as quickly as possible. Results found the glucose and fructose mixture had an 8% quicker time to completion when compared to the glucose drink and 19% quicker time completion than with water. In addition, the glucose-fructose mixture led to sparing of endogenous carbohydrate stores.

In another study (Pfeiffer et al., 2010), eight well trained cyclists were tested, but this time using three separate trials where they cycled 180 minutes. Each subject received one of the three treatments in a random order: water, gel (semisolid) and a drink solution. The gel and the drink solution were both made of the same products, maltodextrin and fructose, and it was found that both the gel and drink were oxidized to the same degree. This is important to note because it shows that the gastric emptying rate of either a gel or drink has no effect on the oxidation rate of the carbohydrate ingested. It is what the substance consists of that is most important.

Effect of Carbohydrate Ingestion on Anaerobic Exercise

Studies support the use of carbohydrates in aerobic activity, but it is still debatable whether carbohydrate intake will benefit anaerobic activity in general, but mainly as a pre-workout regimen. Because anaerobic activity is not as long in duration as aerobic activity, supplementing carbohydrates during exercise is not needed or is difficult to execute. It is thought that carbohydrate ingestion may not be necessary for shorter distance events, and if there is an improvement, it would be caused by a placebo effect (Earniest et al., 2004). Rotstein et al., (2007) conducted a double-blind, randomized study to examine the effect of pre-test carbohydrate ingestion on anaerobic threshold on fifteen competitive male runners. Subjects were not required to fast before testing, but were required to refrain from exercise for 24 hours preceding the test. They were given either 300 mL of a sports drink consisting of 21 grams of carbohydrates (sucrose and maltose-rich glucose syrup) or an orange flavored placebo drink. They were tested twice on each trial day, with two different running tests. Subjects were instructed to drink the sports drink or placebo 30 minutes before the first test began and again during the recovery period before the second running test. Results found that pre-test carbohydrate ingestion had no effect on lactate-minimum speed or the lactate-minimum test-estimated anaerobic threshold.

A review article by Phillips, Sproule, and Turner (2011), reported that sprint performance following carbohydrate ingestion can be attributed to maintenance of blood glucose levels. This regime helps to maintain the central nervous system and give better power output and muscle glycogen sparing. This, of course, is arguable because sprinting activities require more phosphocreatine availability rather than glycogen availability. Ali, Williams, Nicholas, and Foskett (2007) conducted a study looking at sixteen university soccer players and the effect of ingesting a carbohydrate-electrolyte solution on soccer passing and shooting performance during an intermittent shuttle running test. The night before the test, subjects completed a glycogen-reducing cycling exercise and were fed a low-carbohydrate meal and reported the next morning after a ten hour fast. They were each tested with a sports drink containing 6.4% carbohydrate and again with an artificially sweetened placebo with no carbohydrate, in random order. They ingested treatments before exercise, and then every 15 minutes during exercise. Researchers found that the subjects who had compromised glycogen stores performed better on skill tests and sprint performance with carbohydrate ingestion compared to no carbohydrate consumption.

Some researchers, such as Phillips et al., (2011), question the validity of Ali et al., (2007) research. Carbohydrates may have only had an effect because subjects' glycogen levels were depleted. It can be argued that short-duration, maximal intensity exercise can be satisfied with carbohydrate supplementation if the muscle glycogen levels fall below a critical threshold. In Ali et al. study, carbohydrates may have had an effect because subjects' muscle glycogen levels fell below that critical threshold. Although phosphocreatine resynthesis is most important when sprinting, in order to maintain optimal performance an athlete may need some glycogen to maintain anaerobic capacity, recover between sprints, and produce the same level of power repeatedly.

Different Types of Carbohydrates in Exercise

Fernandez, et al. (2010) investigated intake of different carbohydrates on anaerobic and aerobic exercise to see if the vasodilation of vascular endothelium would occur with either or both treatments in anaerobic and aerobic activity showing improved glucoregulation and increased blood flow. Subjects' diets were controlled for two weeks and a cross over design was used so each subject had both treatments with each exercise design. The treatments were glucose or a mixture of glucose and fructose. The study found that during anaerobic exercise the fructose/glucose mixture showed an increase in vasodilation when compared to the glucose mixture. In addition, there were two peaks in plasma glucose and insulin in the fructose/glucose mixture during the anaerobic exercise trial. The second peak could have been caused by a second release of glucose from the liver. This could be after the conversion of fructose. No change was seen during aerobic exercise with the fructose/glucose mixture or glucose mixture.

Honey is made up of monosaccharides, mainly fructose and glucose, along with different oligosaccharides (Bogdanov et al., 2008). This makes honey a great natural supplement for anaerobic activity based on previous research findings because consumption of a glucose and fructose mixture has been shown regulate heart rate and lower rates of perceived exertion (de Oliverira & Burini, 2011). However, with the addition of fructose, individuals may experience gastrointestinal distress. Fructose can slow water absorption and gastric emptying. These factors can lead to issues such as bloating, nausea, diarrhea, and stomach cramps.

Gastrointestinal Distress with Carbohydrates in Exercise

A potential problem with ingestion of carbohydrates, especially sugars, is the possibility of gastrointestinal distress. Exercise-induced gastrointestinal distress symptoms among athletes include dizziness, nausea, stomach or intestinal cramping, vomiting, and diarrhea. The most severe are vomiting and diarrhea which seem to occur mainly during running. Some believe this could be a result of abnormal movements in the gut, but past research has reported a relationship between nutritional practices and GI complaints. Before exercise (<1 hour), it is important to ingest carbohydrate snacks that can be rapidly absorbed, but in moderation. Too many high glycemic carbohydrates can cause a spike in insulin that may decrease performance too early in training (Austin & Seebohar, 2011). In order to avoid gastrointestinal distress, one should ingest a carbohydrate and sodium beverage which consists of less than 10% carbohydrates. Recommendations typically say to use a beverage that contains 6-8% carbohydrates (de Oliveira & Burini, 2011).

Certain forms of carbohydrates, liquid vs. gel, may potentially cause more distress than others. In 2010, Pfeiffer, Stellingwerff, Zaltas, and Jeukendrup stated that in previous research, ingestion of carbohydrates showed a relationship with GI distress. In this study, carbohydrates in a semisolid (gel) and liquid mixture (drink), along with a placebo, were compared for GI distress. The carbohydrate consisted of 2:1 glucose to fructose in both treatments. Trained cyclists (n=8) performed three different trials and received treatments in a random order. Results showed exogenous carbohydrate oxidation is reached to the same degree in a carbohydrate drink and semisolid. More importantly, subjects in this study showed no significant signs of GI distress with liquid or gel. In a study that looked at distance runners and the effect of carbohydrate ingestion, a small amount of participants reported some gastrointestinal discomfort with sports gels that affected their performance (Burke, Wood, Pyne, Telford, & Saunders, 2005). This may have been because the participants were not used to consuming gels. With some practice, over time, the GI distress may subside. More recent studies have shown very little discomfort with carbohydrate ingestion. Pfeiffer, Cotterill, Grathwohl, Stellingwerff, and Jeukendrup (2009) found that despite a high carbohydrate gel intake, regardless of composition, the GI symptoms were insignificant for the majority of participants. However, a small percentage did experience serious issues, possibly caused by individual eating habits.

Honey Compared to Other Carbohydrate Sources

Since honey resembles a form similar to sports gels, studies have been designed to compare the two. Kreider, Rasmussen, Lancaster, Kerksick, and Greenwood (2002) conducted several studies finding that the carbohydrate profile and glycemic index response to honey was almost identical to that of a popular sports gel. The studies consisted of honey consumed before and after resistance training and results showed no physical or psychological signs of hypoglycemia in fasted subjects, a possible cause of gastrointestinal distress. More recently, Kreider, et al., (2002) shifted focus to identify if prior results would apply to endurance cycling. In this double-blind study, subjects ingested honey, a sports gel, or a placebo all packaged in a generic foil packet, before and every 10 miles during a 40 mile cycling trial. Results showed that performance times, power, and mean heart rate were higher with ingestion of the honey and gel. These findings show that honey can improve performance in an aerobic event like cycling by improving carbohydrate availability and work output.

Emphasizing anaerobic performance, Kreider et al., (2007) looked at the difference of ingesting protein along with different carbohydrates during and after exercise. The three carbohydrates used were 120 grams of sucrose, honey powder, or maltodextrin along with 40 grams of whey protein. Resistance trained subjects (n=40), male and female, completed a standardized resistance training workout. Results found no significant differences in the forms of CHO ingested on insulin levels for post-exercise. However, it was discovered that glucose levels were maintained to a higher degree in the honey group. This is important to note because when compared to common sugars used in sports drinks and gels, honey provided a more consistent level of blood glucose during resistance exercise.

In 2010, seven wrestlers participated in a study examining the effects of honey on blood glucose levels and body temperature over the course of two weeks. Subjects' blood, and body and skin temperature were taken prior to and after the two week protocol. A honey and water mixture was used with a ratio of 1:2 (100 grams of honey to 200 grams of water). The mixture was ingested before training (30:60 grams), during training (40:60 grams), and after training (30:60 grams) for each training session for two weeks. Results showed that although honey had no significant effect on internal body temperature, skin temperature was reduced and blood glucose was enhanced due to honey's moderating effect on blood glucose. Therefore, the wrestlers were able to exert more energy and reduce fatigue because of regulated skin temperature (Yosef & Shalaby, 2010).

Testing

Anaerobic capacity is the ability to recover between sprints and produce the same level of power repeatedly. A common way to test anaerobic capacity is the Wingate Anaerobic Test. The Wingate uses peak power and mean power as indices of anaerobic power and capacity. Values of the Wingate have been used to compare subjects in different conditions (Legaz-Arrese, Munguia-Izquierdo, Carranza-Garcia, & Torres-Davila, 2011). Laurent, Meyers, Robinson, and Green (2007) state that the 30 second Wingate anaerobic test is the most widely accepted protocol for measuring anaerobic response. In addition, a 20 second Wingate can be used as a valid alternative for the 30 second Wingate.

However, many sports deal with multiple sprint activity, including basketball, soccer, and football. One study compared the Wingate test to elite runners of varied distances (100 meters to 3,000 meters). Researchers were unable to associate running performance with scores achieved on the Wingate test. Therefore, this study signified that the Wingate is not a useful tool for the evaluation of elite runners (Legaz-Arrese et al., 2011). Also, participants completing the Wingate test have complained of negative side effects. Laurent et al., (2007) reported that the desired responses of the Wingate test can provoke symptoms of fatigue, headaches, dizziness, and nausea. In addition, if the subjects were aware of possible side effects, it could result in submaximal effort, high attrition rates, or unsuccessful subject completion of sport performance testing. Therefore, specificity of testing and optimal conditions for the subjects are of great concern.

Soccer is a sport of multiple sprints and a good combination of aerobic and anaerobic activity. In order to test something of that nature, repeated sprints are the most efficient method of measurement. Protocols normally involve 20 repetitions or less of near maximal or maximal work lasting between one to ten seconds. All provide a short rest period of approximately 60 seconds or less. This protocol supports high degrees of test-retest reliability to measure peak and mean power output (Glaister et al, 2007). Using this type of test may also reduce participants performing submaximally. In a study using field hockey and soccer position players, Wingate results were compared to a repeated anaerobic sprint test and VO_2 max test. It was determined that application for the Wingate may not be the best test for intermittent-type sports, such as soccer (Aziz & Chuan, 2004).

Aziz and Chuan (2004) makes the point that the challenge for multi-sprint sport athletes is more the ability to repeat maximal effort over and over again throughout the competition than just a single all out effort performance. In 2009, Meckel, Machnai, and Eliakim, examined the relationship of aerobic and anaerobic fitness and repeated sprint tests. Elite adolescent soccer players were tested with the Wingate, anaerobic power test (20-m shuttle run test), and two different kinds of repeated sprint tests. They concluded that although all the tests were valid for desired results, anaerobic performance of repeated brief efforts cause different physiological stress than that of a single trial. Therefore, anaerobic testing procedures should imitate the athlete's specific sports activity pattern.

Validity and reliability concerning the repeated anaerobic sprint test (RAST) protocol was addressed by Zagatto, Beck, and Gobatto in 2009. The study was broken into two different stages. The first part of the study was designed to look at the reliability of the RAST. Subjects were required to run six 35 meter sprints with 10 seconds rest in between. They were tested and retested with results showing that there was no significant difference. The second stage of the test looked at the validity of the RAST using the Wingate test and running tests of 35, 50, 100, 200, and 400 meters. Results showed significant correlations between the peak and mean power and fatigue index of the RAST and Wingate tests. In regards to running performances, all of the RAST variables (except fatigue index and lactate peak) were significantly correlated to the performances, but the mean power/weight in kilograms was not correlated in 100m. Whereas, the Wingate testing variables were only significantly correlated with peak power and the velocity at 35 m and between the mean power/weight in kilograms and the velocity at 200 meters. Therefore, the RAST procedure is reliable and valid and can be used to measure running anaerobic power and predict short-distance performances.

CHAPTER 3

METHODS

Purpose

Because past research has shown that simple carbohydrates positively affect aerobic endurance performance, it is important for athletes to know if it provides advantages in other training preparation. The purpose of this study was to determine whether honey, a low glycemic sugar, 1) had the same positive effect on anaerobic performance in collegiate level male soccer players, 2) had varying results on perceived exertion, and 3) had varying effects on gastrointestinal symptoms.

Participants

The participants of this study were 20 collegiate male soccer players from Georgia Southern University. All participants were volunteers between the ages of 18 to 22 years old. They completed a physical and medical history questionnaire screening for contraindications to physical activity. Participants were asked if they had any food allergies or intolerances prior to the study. Participants, that had a food allergy or food intolerance to the substances in the supplements (glucose, fructose, sugar substitutes), were excluded from the study. Testing was completed during spring conditioning practice. All participants completed an informed consent form prior to participating in the study, and Georgia Southern's Institutional Review Board approved the testing and the overall study.

Instrumentation

This study utilized a repeated anaerobic sprint test (RAST) to measure anaerobic capacity, Borg's RPE scale, and a qualitative analysis where a few questions were asked regarding gastrointestinal distress following the test.

Repeated Anaerobic Sprint Test (RAST): This test was used to measure anaerobic capacity. Marker cones and lines were placed 35 meters apart to show distance to be completed. Two additional cones were placed five meters beyond both of the initial cones. Timing gates were utilized and placed at the marker cones on either side. A stopwatch was used to keep record of the rest periods in between sprints. The single sprint time was recorded and the athlete used the five-meter cone to slow down and return to the 35-meter finishing line. The next sprint was in the opposite direction and began ten seconds after the previous sprint ended. This pattern was repeated until six sprints had been completed. Participants' sprint times were examined and scored using maximum, minimum, mean power, and a fatigue index. Maximum and minimum power were calculated by multiplying the subject's weight by the distance squared (35x35 = 1225) divided by the fastest (or slowest) sprint time. Once these values were determined, the fatigue index was found by subtracting the minimum power from the maximum power and dividing the result by the total time for the six sprints. Reliability and Validity were found by Zagatto, Beck, and Gobatto, in 2009.

Maximum Power, Minimum Power, Average Power, and Fatigue Index: Participants' sprint times were examined and scored using maximum and minimum power and a fatigue index. Maximum and minimum power were calculated by multiplying the subject's weight by the distance squared (35x35 = 1225) divided by the fastest (or slowest) sprint time. Once these values were determined, the fatigue index was found by subtracting the minimum power from the maximum power and dividing the result by the total time for the six sprints. Average power was determined by multiplying the subject's weight by the distance squared (35x35 = 1225) and dividing by each sprint time. Finally, all powers were added together and divided by six ((Zagatto, Beck, & Gobatto, 2009).

<u>Supplements:</u> All subjects received each type of supplement, but at different times. The supplements included: 1) The Placebo: 9.5 ounces of a sugar free, no calorie water (Fruit 2-O, Sunny Delight Beverages, Co. ©2009 Veryfine Products, Inc. Lemon flavor); 2) 9.5 ounces of a sports drink (Mountain Berry Blast PowerAde, Coca Cola © 2011), and 3) 20 grams (~ 1 Tablespoon) of a natural honey (Sasserfrass Hill Bee Farm in Augusta, Georgia) mixed with 3 ounces of water. Supplements were pre-measured and mixed in plastic cups prior to distribution at practice.

<u>Borg's 6-20 RPE scale</u>: This scale was utilized to measure perceived exertion in a subject's bout of physical activity. It is a subjective rating system where a subject records how they feel after an athletic activity. The scale ranges from 6-20, with 6 being extremely light and 20 being the most strenuous ever done; and has a direct correlation to heart rate. Research states that if you multiply the chosen number by 100 you should have the approximate heart rate for the athlete. The validity of this test is criterion-related with the correlation to heart rate and the reliability falls at 0.8. (Psycharakis, 2010).

<u>Qualitative Survey</u>: Each athlete was asked a few questions after they completed the RAST and RPE. These questions were used to assess whether the subjects experienced any GI discomfort during the test and if they did experience symptoms, the severity of them.

Procedure

Subjects were recruited during a practice session where they were notified of the study and asked to complete an informed consent form. They were asked if they have any food allergies or food intolerances to certain foods/substances ensuring safety of ingestion of the supplements. Subjects were randomly assigned to one of three groups (Group 1 – honey, PowerAde, then placebo, Group 2 – PowerAde, placebo, then honey, and Group 3 – placebo, honey, then PowerAde**)** and weighed in on a calibrated scale. Later that week, a specific day was chosen to complete a practice run through of the test to ensure there is no effect in performance due to unfamiliarity of the repeated anaerobic sprint test (RAST). Timing gates were used for the most accurate time for each participant. A certified Georgia Southern athletic trainer was present at all practices and testing sessions. All trainers were certified in first aid and CPR.

During the second week, three specific days were selected for subjects to be tested; Group 1 on Tuesday, Group 2 on Wednesday, and Group 3 on Thursday. The night before their assigned testing day, subjects were asked to record their last meal prior to their overnight fast. On their designated day, subjects reported to practice after an overnight fast (nothing to eat or drink, other than water, for 10 hours). Subjects turned in their food record from the night before and it was kept on file in order to remind participants what they needed to eat the night before their next trial. Group 1 received the honey and water mixture, group 2 received the PowerAde, and group 3 received the placebo on their respective days. The subjects were blinded in terms of what they were receiving. Subjects, in a specific order, were staggered two minutes apart when they received their treatment and there was only one subject testing at a time. After ingestion, subjects performed a brief (~15 minutes) warm-up. Once the warm up was complete, testing began. Sprint times were recorded. When testing was finished, subjects completed the RPE and the qualitative survey regarding GI symptoms. Subjects were reminded that they were performing the test again in exactly one week. Snacks were provided following the RAST.

During the third week, subjects had their pre-test meal journal returned to them, so they knew what to eat the night before, and were reminded via text and email to fast and refrain from exercise. On testing day, with groups on their respective days, followed a crossover design and received a different treatment: group 1 received PowerAde, group 2 received the placebo, and group 3 received the honey. Tests were conducted and times were recorded the same way it was done the previous week. RPE scores were collected and qualitative surveys given, followed by snacks for the subjects.

During the fourth week, subjects returned for their final test. The same procedure was followed for this testing day. Again, subjects were asked to come in a fasted state. In this trial, subjects received the final treatment: group 1 received the placebo, group 2 received the honey, and group 3 received the PowerAde. Tests were conducted and times were recorded. When testing was complete, RPEs were scored, surveys conducted and subjects were given snacks. At the end of the week when all subjects had completed their last test, they were debriefed. Researchers informed each participant what supplements were used in the study, what week they received each supplement, and how each supplement affected their performance and digestive (GI) system.

Data Analysis

The data analyses used were multiple One-Way ANOVAs with repeated measures. The independent variables were the supplements: honey, PowerAde, or the placebo, and the dependent variables were the maximum power, minimum power, mean power, fatigue index, and scores on the RPE. The alpha level was set at 0.05 and the power was 0.8. The results from the qualitative survey were collected, compared, and reported.

Study Timeline

Week 1: Recruited players and had them fill out an informed consent form. They were weighed, divided randomly into groups one and two, and notified of their schedule. On selected day of the week, ran pilot test at the beginning of practice. Conducted warm-up and test just as it was done during testing in order to work out any issues and familiarize subjects with the protocol.

Week 2: Subjects came to practice in a fasted state on their specified day of practice with a copy of the last meal they ate; ingested either honey, PowerAde, or placebo, and performed assessment. Subjects filled out survey, RPE, and were reminded about testing the following week.

Week 3: Subjects came to practice in a fasted state on their specified day of practice after eating the same meal they did the previous week prior to testing; ingested either honey, PowerAde, or placebo, and performed assessment. Subjects filled out survey, RPE, and were reminded about testing the following week.

Week 4: Subjects came to practice in a fasted state on their specified day of practice after eating the same meal they did the previous two weeks prior to testing; ingested the last treatment from the two weeks prior, and performed assessment. Subjects filled out survey, and RPE. At the end of the week, subjects were debriefed on the study. They were informed about what the different treatments were, what group they were assigned to, and how they performed after ingesting each supplement.

CHAPTER 4

RESULTS

The study began with 20 collegiate male soccer players (19.39 ± 0.85 yr, 75.39 ± 7.97 kg) with 18 completing the study. Two dropped out due to injury and team issues. The remaining 18 participants completed all of the required protocols to partake in the study. The participants' descriptive statistics are reported in Table 4.1.

Table 4.1 – Demographics of testing population

N=18	Mean	Standard Deviation
Age	19.39	0.85
Weight (kg)	75.39	7.97

Each participant was questioned prior to each testing session regarding fasting and consuming the same meal the night before. Each reported compliance with the procedure.

When looking at maximum power output, Mauchly's test indicated that the assumption of sphericity was violated, $X^2(2) = 9.04$, $p<0.05$, therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of spherictiy ($\varepsilon= 0.70$). The results showed neither honey, PowerAde, nor placebo had a significant effect on maximum power output, $F(1.40, 23.75)=.044$, $p>0.05$. Descriptive statistics are reported in Table 4.2 and Figure 4.1.

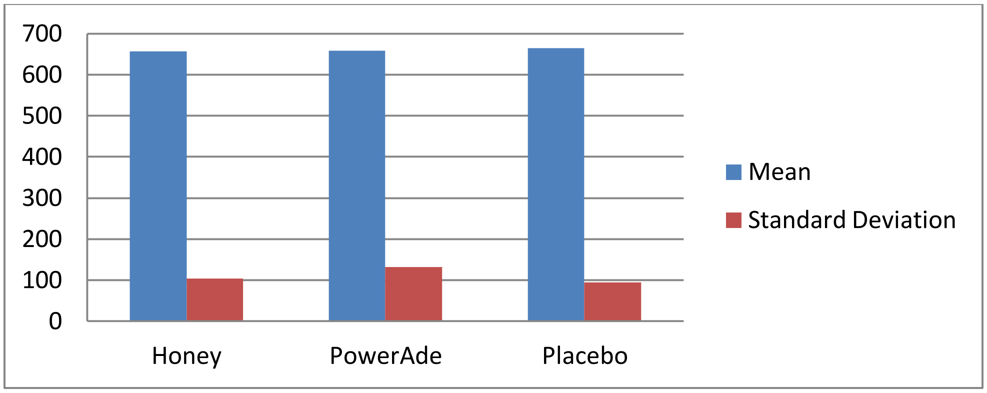

Figure 4.1: Maximum Power Output for each supplement over the course of three weeks. No significance was found in comparison of the supplements (p>0.05)

In the analysis of minimum power output, Mauchly's test indicated that the assumption of sphericity was assumed, $X^2(2) = 3.18$, $p>0.05$. After reviewing the data, neither honey, PowerAde, nor placebo had a significant effect on minimum power output, $F(2, 34)=.988$, $p>0.05$. Table 4.2 and Figure 4.2 summarize the descriptive statistics.

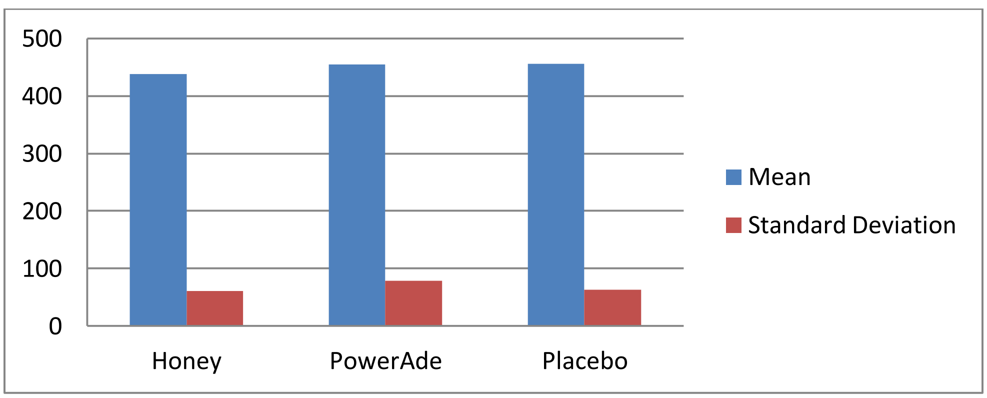

Figure 4.2: Minimum Power Output for each supplement over the course of three weeks. No significance was found in comparison of the supplements (p>0.05)

For the mean power output, Mauchly's test indicated that the assumption of sphericity was assumed, $X^2(2) = 5.30$, $p>0.05$. Neither honey, PowerAde, nor placebo showed significant results of an effect on mean power output, $F(2, 34)=.918$, $p>0.05$. Descriptive statistics are summarized in Table 4.2 and Figure 4.3.

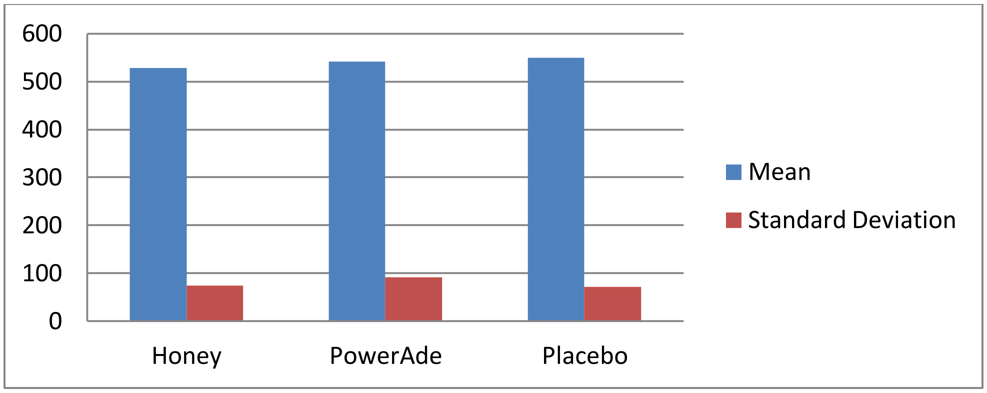

Figure 4.3: Mean Power Output for each supplement over the course of three weeks. No significance was found in comparison of the supplements (p>0.05)

When looking at fatigue index, Mauchly's test indicated that the assumption of sphericity was assumed, $X^2(2) = 3.39$, $p>0.05$. The results showed neither honey, PowerAde, nor placebo had a significant effect on fatigue index, $F(2, 34)=.22$, $p>0.05$. Descriptive statistics are reviewed in Table 4.2 and Figure 4.4.

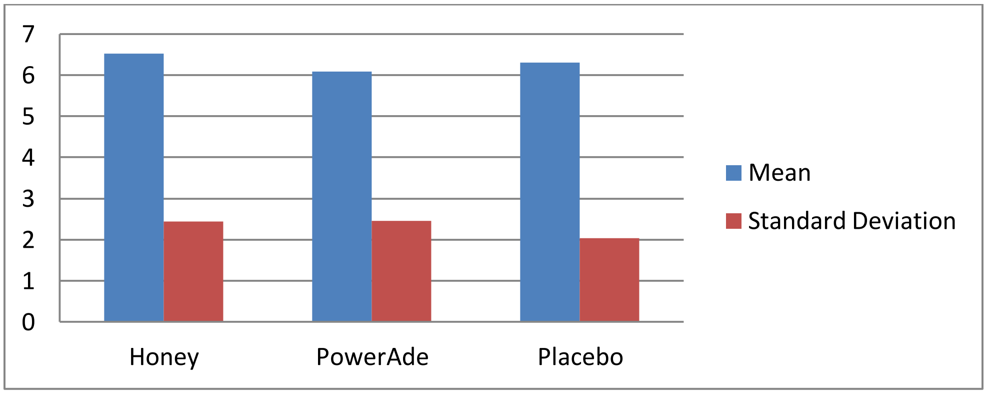

Figure 4.4: Fatigue Index for each supplement over the course of three weeks. No significance was found in comparison of the supplements (p>0.05)

In the analysis of rate of perceived exertion (RPE), Mauchly's test indicated that the assumption of sphericity was assumed, $X^2(2) = 4.30$, $p>0.05$. No significance was observed for RPE with honey, PowerAde, or placebo, $F(2, 34)=3.19$, $p>0.05$. Table 4.2 and Figure 4.5 report all of the descriptive statistics.

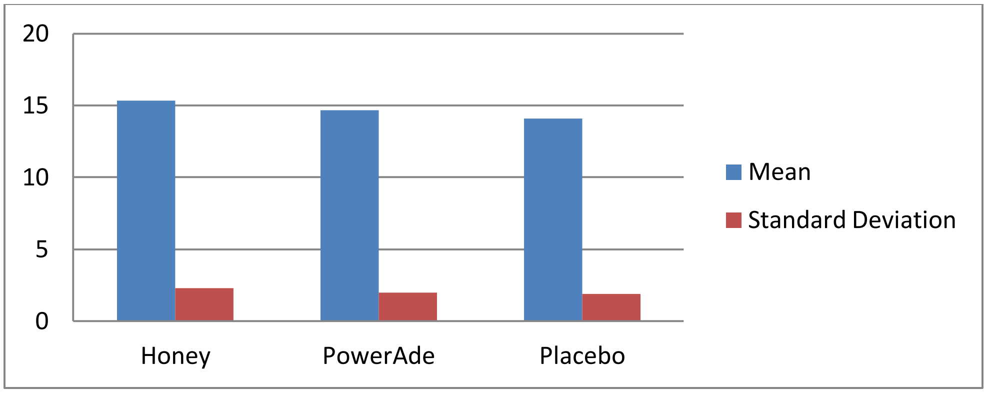

Figure 4.5: Rate of Perceived Exertion Scores for each supplement over the course of three weeks. No significance was found in comparison of the supplements (p>0.05)

Table 4.2 – Mean, Standard Deviation, and P-values of each supplement over the three week testing period.

	Honey		PowerAde		Placebo		P-Value
	Mean	SD	Mean	SD	Mean	SD	
Max Power	657.49	103.96	658.26	131.17	664.17	95.12	.905
Min Power	438.01	60.23	454.19	78.23	455.56	63.26	.383
Mean Power	528.09	73.66	541.95	91.58	549.47	71.02	.409
Fatigue Index	6.52	2.44	6.09	2.56	6.30	2.04	.803
RPE	15.33	2.28	14.67	1.97	14.11	1.91	.054

Qualitative Results: GI Distress

In regards to GI distress reported, side effects were minimal. Subjects were asked if they experienced any of the following symptoms during or following the RAST: bloating, stomach cramps, nausea, or diarrhea. Seventy-eight percent of the participants reported no GI distress with any of the supplements. One subject reported moderate stomach cramps after ingesting the placebo, one reported mild bloating after ingesting the PowerAde, one reported mild bloating with all three supplements, and two others reported nausea with all three supplements. One of the subjects that reported nausea, stayed consistent reporting moderate each time, however, the other reported varying severity. He experienced extreme nausea with the placebo, moderate with the honey, and moderate with the PowerAde. Some of these participants in particular, stated the amount of supplement they received was part of the problem.

CHAPTER 5

DISCUSSION

This study was one of the first to examine the results of using honey as an ergogenic aid in a single bout of anaerobic performance. The study began with 20 collegiate male soccer players, with 18 completing the study. Two dropped out due to injury and team issues. Even with the loss of two participants, in a post-hoc evaluation, this study shows to have enough power (≥ 0.8). The remaining 18 participants completed all of the required protocols to partake in the study. During the three weeks, participants ingested three different supplements (honey, PowerAde, and a placebo of flavored water) in random order, 15 minutes prior to running a repeated anaerobic sprint test to evaluate maximum, minimum, and mean power, and fatigue index. Participants were also asked to rate their perceived exertion and answer questions regarding gastrointestinal distress. At the completion of the study, maximum, minimum, mean power, and fatigue index were not affected by any of the supplements. As well as, rate of perceived exertion showed no difference related to supplementation. A few participants reported signs of gastrointestinal distress, but they seemed to be fairly consistent throughout the testing period regardless of the supplement ingested.

The results of the physiological data are interesting given the previous research on carbohydrate supplementation and anaerobic performance. Although, there were no significant results regarding honey and PowerAde as a carbohydrate supplement, there were also no results with a placebo supplement. Earniest et al., (2004) stated that any improvement in performance with carbohydrate ingestion and anaerobic exercise may be the results of a placebo effect. Because there was no significance found with any of the variables and the supplement comparisons, in this particular study, there seems to be no results from a placebo effect. This finding was similar to another study (Rotstein et al., 2007) that observed no difference between a carbohydrate drink and placebo drink in anaerobic threshold in distance runners. Results from this study differ from those in Ali, Williams, Nicholas, and Foskett (2007). That study also evaluated soccer players and it found a significant improvement on skills tests and sprint performance when comparing carbohydrate ingestion to no carbohydrate ingestion. This is intriguing because there was no significance found in this investigation with either carbohydrate ingested versus the placebo. Both studies utilized a ten hour fast prior to testing. However, unlike this study, participants in Ali et al., (2007) completed a glycogen-reducing cycling exercise and fed a specific low carbohydrate meal. They also ingested carbohydrates before, and every 15 minutes during the testing period. Complete glycogen depletion and more frequent supplementation could explain the differences in results.

Kreider et al., (2007) showed the effects of carbohydrate ingestion. It studied a combination of carbohydrates and protein in anaerobic activity, and it found improvement with honey over other carbohydrates. It differs from this investigation because participants were not tested in a single bout of anaerobic performance. In Kreider et al., researchers analyzed performance through resistance training with weightlifting exercises over a 30-40 minute period. Researchers found results with honey maintaining blood glucose levels more significantly than other carbohydrate sources. It is likely, that these results are because honey provides a longer lasting source of energy. Its make-up of mainly fructose forces the body to digest slower, and in turn, cause a spike in energy later in physical activity. Even though the present study did not analyze blood glucose levels, slower digestion and energy spike later in physical activity may be a feasible explanation for why honey showed no significant results in a single bout of anaerobic performance.

The data seems to indicate no trend or tendency of effects on all of the variables. The only finding that shows any trend toward significance is a slight positive/negative tendency in exertion scores. In 2011, de Oliverira and Burini stated that a mixture of glucose and fructose in a carbohydrate supplement has shown to regulate heart rate and decrease rates of perceived exertion. The only issue is that RPE seemed to be the lowest when taking the placebo. Because the supplements were given in random order, the results of this analysis are unclear. However, in a different analysis of the data looking at maximum, minimum, mean power, and fatigue index, along with the RPE scores, when comparing weeks one through three regardless of the type of supplementation, results showed a significant difference of decrease in fatigue from week one to week three. This could explain why the original data showed no significance in regards to the dependent variables. The chances that the participants either altered the way they took the test, or got better at running it over the course of three weeks, is highly likely. Therefore, the participants that received the honey or PowerAde on their first day could have been at a disadvantage when compared to the participants that had those supplements on their last day of testing.

As far as gastrointestinal distress is concerned, some of the participants experienced some bloating and nausea, but symptoms were mild. These findings are relative to those found in Pfeiffer, Cotterill, Grathwohl, Stellingwerff, and Jeukendrup (2009) where there were no significant issues with GI distress and problems that did arise may be caused by unfamiliarity of ingestion before exercise or the participants' personal eating habits. To emphasize this assumption, it seemed that the participants who did have GI distress had more distress when ingesting the flavored water rather than the actual carbohydrate supplementation. This is important to note because even though there was no difference in performance than the participants, there was also no detriment to any of the participants. This finding may encourage participants who realize or perceive improved performance with carbohydrate supplementation to switch to a natural carbohydrate source, such as honey.

If someone prefers or chooses honey over a different workout supplement, it may yield additional benefits to athletes over and above performance improvement. For example, because the participants in this study are soccer players, the type of energy systems used vary at different points during a game and practice. Because practices last for approximately two hours and games last for 90 minutes, honey would be a great choice to use as a pre-game/pre-exercise supplement. Because research supports that honey and/or carbohydrates are beneficial for aerobic activity (Ali et al., 2007; Campbell et al., 2008; Kreider, et al., 2002), an athlete knowing that honey does not hinder sprint performance in the early stages of digestion or cause any abnormal GI distress, may utilize honey even more. It would have been interesting to see if the participants felt different during practice after taking different supplements following the RAST.

Athletes and active individuals, deal with ailments like inflammation, low immune systems, and oxidative stress. With all of the physical stress that the body endures during physical activity, muscles become inflamed, injuries occur, and the body may not always have time to recover. By supplementing honey for performance reasons, the athlete also realizes the benefits of decreased inflammation, improved immune function and lower oxidative stress. Al-Waili and Boni (2003) found that inflammatory markers like thromboxane B(2), PGE(2), and PGF(2a) all decreased over the course of 15 days. A low immune system is of concern for athletes in that they are exposed to heightened immune threats in gyms and training areas as well as heightened vulnerability due to exhausting workouts and competitions. Sometimes the body gets so run down, the immune system cannot fight off infections. Many times athletes will ignore warning signs and push through injury issues because of their training and competiveness. They feel they have to because missing a day of training may jeopardize their perceived competitive edge. By supplementing honey, athletes can continue to improve their immunity by inducing the immunity boosting characteristics in the components of honey. In cell cultures, honey stimulated B-lymphocytes and T-lymphocytes to multiply and activate neutrophils. By stimulating monocytes, cytokines TNF-alpha, IL-1, and IL-6 are released. These can activate the immune response to infection (Manyi-Loh, Clark, & Ndip, 2011). Molan in 2001, showed that because of the high content of glucose in honey, macrophages can use that glucose to produce hydrogen peroxide in what is referred to as a "respiratory burst." This is what macrophages use to supplement their bacteria-destroying activity.

And finally, exercise puts an extra amount of stress on the body that causes oxidative reactions producing free radicals. If free radicals are consistently present in excess, they could cause cell damage or death, which often leads to disease. The body uses antioxidants to rid the body of free radicals and help prevent oxidative reactions to avoid damage. Honey has antioxidant properties. Bogdanov, Jurendic, Sieber, and Gallmann found in 2008 that total plasma total-phenolic content increased along with plasma antioxidant and reducing capabilities with the consumption of buckwheat honey compared with corn syrup. By choosing honey as a supplement, the antioxidant activity of plasma can be increased with the bioavailability of phenolic antioxidants.

The current study showed honey had no adverse affect on the participants different than flavored water or PowerAde. It can be extrapolated from previous research, and because of honey's unique health benefits, especially for physical activity and the effect on aerobic activity, that honey would appear to be the smarter and more beneficial choice.

Limitations

There were several limitations that accompanied the study that may have altered the data. All participants were required to fast and refrain from any outside exercise ten hours prior to testing, as well as eat the same meal the night before each testing period. Participants' meals were recorded and sent to them prior to each testing day, but the guarantee that each participant followed the protocol is up for debate. Because the participants were not in a controlled setting it is hard to determine if the correct meal was eaten and that they did not eat anything or exercise ten hours preceding practice. This may have had an effect on performance because glycogen stores may not have been depleted or the additional exercise may have caused fatigue that was not present on other trials. These factors may not have allowed them to perform to the best of their abilities.

During the testing period, a couple participants suffered some muscle tweaks that may have affected their performance as well. It seemed, however, the limitation that affected the data the most, was effort on the RAST. There was a noticeable difference in the effort that was given on the first day of testing compared to the last day. Participants seemed to be pacing themselves rather than going all out. This was seen in some of the participants' slowest sprint was their third sprint, rather than the last or second to last sprint. Because participants may not have been exerting maximal effort, this may have affected the results. From additional analysis of the data, comparing the days of the week regardless of supplementation, results show that the fatigue index was least on the third week of testing. Their fatigue gradually decreased, as the study progressed. This could be a result of effort levels being compromised or a training effect.

It was noted that although the test was supposed to get participants to give maximal effort, the scores on their RPEs did not reflect that outcome. Many participants' scores were "light," "somewhat hard," and "hard." The expectations were that the scores would be very hard, extremely hard, or maximal exertion. After questioning some of the participants, they claimed the tests were hard while running, but their recovery time was minimal. Some athletes said it was more difficult than they anticipated; however, it was not as hard as their normal practice. Because they are soccer players and tend to exert themselves over a longer period of time, they may have a different perception of maximal effort. Their normal workouts require them to constantly regulate their effort to the requirements and situations in the game of soccer, which is a running clock sport. They are therefore rarely "spent" at the end of an effort. An all out effort of a sprinter, may have been a better fit for the type of testing utilized in this study. The exertion exhibited by the subjects in this study was likely different from that which was expected in this investigation. One of the participants who was not privy to the exam's methodology even stated that the drill was hard while running, but because he recovered more quickly than after a game, he felt that the score should be "somewhat hard." This statement reveals what may have been a defect in assumptions made concerning the test group and their expected effort.

Some other limitations detected that were unexpected included the length of testing and athletic abilities of the participants. In previous research of anaerobic performance and carbohydrate ingestion (Ali et al., 2007; Kreider et al., 2007) positive results have occurred, even with the usage of honey. The difference between the current study and this research is that the times to completion of the anaerobic tests vary in lengths. In the current study, the RAST took approximately 90 seconds to complete. In previous research, anaerobic performance was evaluated over lengths of time, such as 30-40 minutes or longer. Although, anaerobic skills were evaluated, other energy systems were needed. These athletes would have also utilized the aerobic energy system to accomplish the tasks they were asked to complete. Therefore, significance in this study may have been absent due to the RAST being too short.

With duration still in mind, the participants' athletic ability and physical shape may have also played a role in the results found in this study. Because collegiate athletes are at an elite level of sport, many possess mental toughness and physical ability to complete activities beyond the average person. Collegiate athletes are also very aware of their bodies and know when to push beyond exhaustion. With the duration of the RAST being so short, these participants in particular may have been able to power through and give a strong performance regardless of what supplement they took or even under an overnight fast. These statistics would be difficult to generalize for the average population because our testing population embodies people with elite athletic and performance skills.

Future Research

While the present study found no significant results with any of the supplements, this study should be replicated with a few alterations. Considering past research, and the findings that carbohydrate supplementation improves performance after glycogen depletion in a fasted state, common sense dictates there should be an advantage with at least one of the carbohydrate supplements. Therefore, characteristics may need to be adjusted to confirm the original hypotheses. Some proposed changes would include the amount of supplement ingested before testing, the amount of time allowed for digestion, using fasted and non-fasted participants, the type of repeated anaerobic sprint test used, and the selection of participants.

In identifying possible improvements to the study, supplement quantities is the first order. The assumption that administering a carbohydrate supplement to a participant in a fasted state would readily identify a benefit to performance may have been in error. If this study is replicated, the researcher should contemplate increasing the supplement amount dispensed before each trial. It is likely that the amount in this study was insufficient to fuel performance results superior to that of a placebo. Participants may have been in such a glycogen deficit that the amounts were enough to provide some energy but not enough for noticeable improvement over the placebo. Research also suggests that supplementation shows results when based on a person's bodyweight (Al-Waili & Boni, 2003; Burke, Wood, Pyne, Telford, & Saunders, 2005; Schramm et al., 2003). With the sizes of subjects varying greatly, it would be important to gauge the amount of supplement relatively.

Time allowed for digestion could have also posed a problem for the participants in this study. Fifteen minutes may not have been enough time for the body to absorb and utilize sugars from the PowerAde or the honey. A number of studies that were researched for this experiment utilized supplementation throughout testing. They each used intervals of time between supplementations. A common amount of time used was 15 minutes between doses (Ali et al, 2007; Pfeiffer, Stellingwerff, Zaltas, & Jeukendrup, 2010). Haff, Lehmkuhl, McCoy, and Stone, (2003), reviewed studies that used intervals of ten minutes for resistance training sessions. Because there were positive results with the previous studies, 15 minutes seemed to be a reasonable time to allow for digestion. If this study were to be replicated, the researchers may need to revisit time for digestion and absorption, along with possibly increasing the amount of supplement given.

Because we did not find any significance over the placebo, the problem may not have been the supplements. An additional improvement to the study would be to analyze fasted versus non-fasted subjects along with supplementation. Many times athletes have a routine that they follow on a daily basis. Although we did not alter their diet at all, we did require them to complete an overnight fast. By asking them to do this, they may have been thrown off and not been able to perform to the best of their abilities. Problems also may have occurred due to them only being off schedule once a week. Their bodies were never able to adjust or adapt to the fasted state, possibly causing different results than if they were on their regular diet. By using a fasted versus non-fasted state and the same supplement, more significant results might be found.

Another component of the study that could be modified is the type of test administered. Although participants performed a "dry-run" of this particular sprint test, they were still perfecting its execution by the end of testing. By using a more familiar protocol, participants may spend less time mastering technique. Perhaps the selection of an anaerobic skill drill already utilized by the participants would be more appropriate. Since execution is already mastered, any improvements in performance may be attributed directly to each type of supplement. As discussed earlier in the limitations, a testing protocol lasting longer than 90 seconds may heed better results.

Finally, the selection of participants may need refining. Soccer, while considered a sport that exhibits anaerobic activity, often attracts a hybrid athlete. These athletes demonstrate characteristics of refined aerobic and anaerobic energy systems. Future selection should focus on athletes whose sport consists mainly of maximal effort anaerobic activity. Some examples include sprinters, jumpers, gymnasts, football players, and power sports. Consideration of recreational athletes may also be appropriate, given that their efforts may be more genuine. These changes may yield more definitive performance results.

Studies routinely build on one another to bridge knowledge gaps. The findings in this study were inconclusive, but characteristics of its examination provided impetus for further research utilizing refined methods. Knowing that carbohydrate supplementation in a fasted state yields energy for the body, honey and PowerAde should have enhanced performance. Therefore, an inadequacy may exist in the methodology of this study. Adjusting the amount of supplement ingested before testing, the amount of time allowed for digestion and absorption, using a fasted versus non-fasted state, the type of testing protocol utilized, and the participant selection may achieve findings supporting the hypotheses. Only further study of these hypotheses, under varying protocols will accurately reveal a connection between supplementation and increased anaerobic performance.

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APPENDIX A

INSTRUMENTS

Demographics Collection and Group Assignment

Demographics:

Name: ____

Group: Group 1   Group 2   Group 3

Age: ________________

Weight: ____________

Do you have any food allergies?   Yes   No
If yes, what are they?
____
____

Email address:
____

Phone Number: ______________________________

Repeated Anaerobic Sprint Test (RAST)

The repeated anaerobic sprint test was devised at the University of Wolverhampton in the UK and includes six sprints over a distance of 35 meters with a ten second rest between each sprint. The measurements provided are maximum power, mean power, and minimum power, along with a fatigue index.

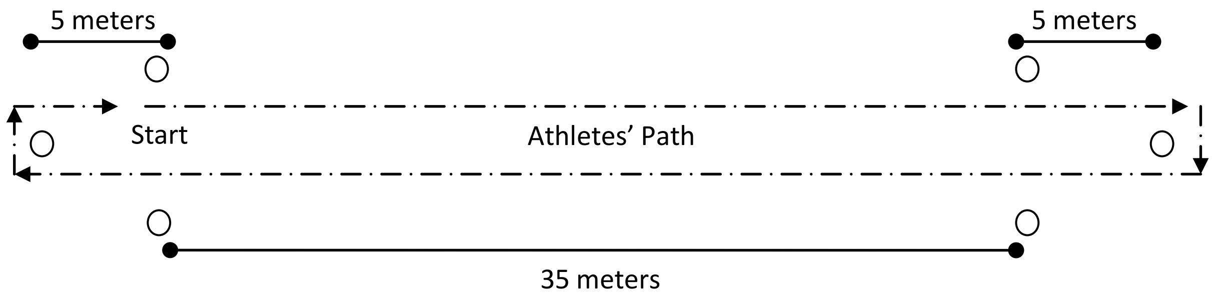
Each participant is weighed prior to testing. Cones were set up at each end of 35 meters along with two timing gates with an additional cone set up 5 meters past the finish line for slowing down. The subject stands at one end of the 35 meter course and starts on his own completing a maximal sprint to the other end of the course. They then have ten seconds to slow down and return to the finish, now starting, line. On “go” they complete another maximal sprint in the opposite direction. This is repeated until six sprints have been completed.

Calculations: Weight (bodyweight of the subject in kg), distance (35 m), and time (seconds to run 35 m). From these values maximum, minimum, and mean power, and a fatigue index can be determined.

$$\text{Power} = \text{Weight x Distance}^2 \div \text{Time}^3$$

$$\text{Power} = \text{Weight x1225} \div \text{Time}^3$$

$$\text{Fatigue Index} = ((\text{Maximum power} - \text{Minimum Power}) \div \text{total time for 6 sprints})$$



Gastrointestinal Distress Questionnaire

Qualitative Survey:

During or following the RAST test, did you experience any of the following?

- ☐ Bloating
- ☐ Stomach Cramps
- ☐ Nausea
- ☐ Diarrhea

If you experienced any of the above symptoms, would you describe them as mild, moderate, or extreme?

Borg’s Rate of Perceived Exertion Scale

Borg’s RPE Scale: Please select a number based on how you felt during the test

Rating	Perceived Effort	Star your Rating
6	No exertion at all	
7	Extremely Light	
8		
9	Very Light	
10		
11	Light	
12		
13	Somewhat Hard	
14		
15	Hard (heavy)	
16		
17	Very Hard	
18		
19	Extremely Hard	
20	Maximal Exertion	

APPENDIX B

IRB INFORMATION

GEORGIA SOUTHERN UNIVERSITY

COLLEGE OF HEALTH AND HUMAN SCIENCES

DEPARTMENT OF HEALTH AND KINESIOLOGY

INFORMED CONSENT

THE EFFECT OF DIFFERENT TYPES OF CARBOHYDRATES ON ANAEROBIC PERFORMANCE IN MALE COLLEGIATE SOCCER PLAYERS

1. **Principle Investigators:** Katelyn Woolfolk, Graduate student, Department of Health and Kinesiology, 321-271-7100.
   Amy Jo Riggs, PhD, RD, Assistant Professor, Department of Health and Kinesiology, 478-7753.

2. **Purpose of the Study**: Because past research has shown that simple carbohydrates positively affect aerobic endurance performance, the purpose of this study is to determine whether different types of carbohydrate will 1) have the same positive effect on anaerobic performance in collegiate level male soccer players, 2) have varying results on perceived exertion, and 3) have varying effects on gastrointestinal symptoms.

3. **Procedures to be followed**: At the beginning of the study, you will be weighed and randomly assigned to one of three groups. You will also be asked if you have any food allergies or intolerances prior to testing. Then, you will have a "mock" run through of a repeated anaerobic sprint test (RAST) to familiarize yourself with the test. This research study will be completed over the course of three weeks, with one testing day per week for each group. During test days, you will be asked to come in after an overnight fast (nothing to eat or drink other than water 10 hours prior to testing) as well as record the last meal you ate prior to the test day and turn it in to the researchers the day of the test. You will be asked to consume the same meal the night before all three trials. Different supplements will be consumed during each testing session (you will not be aware of what supplement you are consuming at that time) in a random order based on group assignment. You will ingest the supplement, follow a 15 minute dynamic warm-up and stretching period, and then perform the RAST. Following the RAST, you will be asked to rate your perceived exertion to determine how you felt during each test. In addition,

you will be asked questions to determine whether you experienced any gastrointestinal discomfort (bloating, stomach cramping, nausea, and diarrhea) during the tests.

4. **Discomforts and Risks**: The risks associated with anaerobic fitness testing are minimal in a healthy population, but may include muscle soreness and possible strained muscles or twisted knee or ankle during the fitness test. Risks will be minimized by using proper warm up and flexibility protocols. Medical care will be available in the event of injury by a Georgia Southern University athletic trainer, but neither financial compensation nor free medical treatment will be provided. Georgia Southern University and the researchers of this study will not be held accountable for any injury that may occur during the time of testing. Additional discomforts that may occur in some individuals include bloating, stomach cramps, nausea, or diarrhea as a result of carbohydrate intake and physical activity. The taste of the supplements may be less appealing to some.

5. **Benefits**: A pre-exercise supplement that is effective in improving performance is beneficial for athletes. Decreasing fatigue and improving anaerobic power can make exercise more enjoyable and improve athletic performance. At the completion of the study, you will find out what the supplements were, the order of supplement you received during the different trails, and how it affected your individual performance.

6. **Duration/Time required from the participant**: Testing and data collection will be conducted during practice so no additional time is required for data collection.

7. **Statement of Confidentiality**: All scientific and personal data collected on subjects for presentation purposes will be kept confidential and stored in a locked file drawer in Hollis 2121A. Data will be kept for three years and this information will only be available to the principle investigators. Neither your identity nor personal health and conditions will be revealed in publications or presentations that result from this study so as to protect your privacy and confidentiality. All data will be reported as means and standard errors.

8. **Right to Ask Questions**: You have the right to ask questions and have those questions answered. If you have questions about this study, please contact Katelyn Woolfolk, 321-271-7100, kwoolfo3@georgiasouthern.edu or Dr. Amy Jo Riggs, PhD, RD., Associate Professor, Department of Health and Kinesiology, 912-478-7753, ajriggs@georgiasouthern.edu. For questions concerning your rights as a research participant, contact Georgia Southern University Office of Research Services and Sponsored Programs at IRB@georgiasouthern.edu or 912-478-0843.

9. **Compensation**: There is no compensation for participating in the present research study.

10. **Voluntary Participation**: Your participation in this study is entirely voluntary. If you decide to participate, you are free to withdraw your consent and to stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

11. **Penalty**: If you decide not to participate, you will not be penalized, and you will not lose any benefits or services to which you are otherwise entitled.

12. You must be 18 years of age or older to consent to participate in this research study. If you consent to participate in this research study and to the terms above, please sign your name and indicate the date below.

You will be given a copy of this consent form to keep for your records. This project has been reviewed and approved by the GSU Institutional Review Board under tracking number H12333.

Title of Project: THE EFFECT OF DIFFERENT CARBOHYDRATES ON ANAEROBIC PERFORMANCE IN MALE COLLEGIATE SOCCER PLAYERS.

Principal Investigators: Katelyn Woolfolk, Graduate Student, 321-271-7100, kwoolfo3@georgiasouthern.edu.

Amy Jo Riggs, Assistant Professor, Department of Health and Kinesiology, 478-7753, ajriggs@georgiasouthern.edu

Other Investigator(s): Stephen Rossi, Ph.D., Associate Professor, 912-478-0775, srossi@georgiasouthern.edu, and A. Barry Joyner, Ph.D, Professor, 912-478-0495, joyner@georgiasouthern.edu.

Faculty Advisor: Amy Jo Riggs-Deckard, Ph.D, RD, LD, Assistant Professor, 912-478-7753, ajriggs@georgiasouthern.edu.

______________________________________ ____________________

Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed.

______________________________________ ____________________

Investigator Signature Date

Instructions: *Please respond to the following as briefly as possible, but keep in mind that your responses will affect the actions of the Board. Clearly label your responses in sections that correspond to the specific information requested. The Narrative should include a step by step plan of how you will obtain your subjects, conduct the research and analyze the data. Make sure the narrative clearly explains aspects of the methodology that provide protections for your human subjects. You may insert your responses in each section on this page in bold text, leaving a space between the question and your answers. Narrative should not exceed 5 pages.*

The application should be submitted electronically (email attachment) or sent to the Office of Research Services and Sponsored Programs, at P. O. Box 8005, Statesboro, GA 30460, fax (912) 478-0719, and should contain, in this order: a signed cover page (fax, pdf or mail), the project proposal narrative, signed copy of certification of investigator responsibility (CIR) (fax, pdf or mail), human subject training certificate (within the last 3 years), and the informed consent that you will use in your project., the informed consent checklist (optional) Additional information, such as copies of survey instruments, letter of cooperation from institutions where subjects will be accessed (e.g., public schools), advertisements, or any instruments used to interact with participants should be attached at the end of the proposal clearly designated as an Appendix. ***For electronic submission:*** *First complete the proposal narrative in entirety and "Save As" a word document to your computer or disk named "lastname, First initial _propnarr_Year_Month_Date.doc". Open and complete cover page. Email all documents to IRB@georgiasouthern.edu. Documents that require signature may be faxed to 912-478-0719, mailed or uploaded in PDF. (Electronic submission is not required.)*

Personnel.

Katelyn Woolfolk, Principle Investigator, 321-271-7100, kwoolfo3@georgiasouthern.edu, Amy Jo Riggs-Deckard, Ph.D, RD, LD, Assistant Professor, 912-478-7753, ajriggs@georgiasouthern.edu, Stephen Rossi, Ph.D., Associate Professor, 912-478-0775, srossi@georgiasouthern.edu, and A. Barry Joyner, Ph.D, Department Chair and Professor, 912-478-0495, joyner@georgiasouthern.edu, Department of Health and Kinesiology, P.O. Box 8076, Statesboro, GA 30460

Roles of Personnel

Name	Access to Subject Info	Recruit-ment	Administration of RAST	Administration of RPE and qualitative survey	Data Analysis	Manuscript
Woolfolk	X	X	X	X	X	X
Riggs	X			X		X
Joyner	X				X	
Rossi	X		X	X		

Purpose. Because past research has shown that simple carbohydrates positively affect aerobic endurance performance, the purpose of this study is to determine whether honey, a low glycemic sugar, will 1) have the same positive effect on anaerobic performance in collegiate level male soccer players, 2) have varying results on perceived exertion, and 3) have varying effects on gastrointestinal symptoms.

Using pre- or peri-workout supplements has become progressively more popular among recreational and elite athletes. Most of this stems from studies that suggest that aerobic and anaerobic performance can be improved with the ingestion of supplements and recommendations from expert panels in sports nutrition (Schmitz et al., 2010). Athletes use dietary supplements with the assumption that their performance will improve. However, supplements are often used without a full understanding of the potential benefits and/or risks (Maughan, Depiesse, & Geyer, 2007). Therefore, it is important for athletes to understand what is in a supplement, how it works, and how it may affect health and performance.

When a person exercises at a high intensity or for long periods of time, glycogen stores are depleted and need to be replenished. Ingesting carbohydrates can improve one's performance by maintaining blood glucose levels and sparing liver glycogen (Campbell, Prince, Braun, Applegate, Casazza, 2008). Past research on carbohydrate ingestion has mostly focused on the effects on aerobic capacity because carbohydrate oxidation and glycogen depletion normally occur during aerobic activity. Because carbohydrate oxidation increases between 70-95 minutes of exercise, it is imperative that athletes practice carbohydrate intake to achieve maximal performance (Earniest et al., 2004). During exercise, athletes want to limit the use of liver glycogen as a source of energy. By preserving liver glycogen, an athlete can work out harder and longer. Ingesting carbohydrates while exercising can reduce and replace hepatic glucose production, which is the sparing of liver glycogen (Wallis, Dawson, Achten, Webber, & Jeukendrup, 2006).

Studies support the use of carbohydrates in aerobic activity, but it is still debatable whether carbohydrate intake will benefit anaerobic activity. It is thought that carbohydrate ingestion may not be necessary for shorter distance events and that if there is an improvement, it would be caused by a placebo effect (Earniest et al., 2004). Rotstein, Dotan, Zigel, Greenberg, Benjamini, & Falk (2007) found that pre-test carbohydrate ingestion had no effect on lactate-minimum speed or the lactate-minimum test-estimated anaerobic threshold. Phillips, Sproule, & Turner (2011), reported that sprint performance following carbohydrate ingestion can be attributed to maintenance of blood glucose levels. This helps to maintain the central nervous system and give better power output and muscle glycogen sparing. They also state that short-duration; maximal intensity exercise can be satisfied with carbohydrate supplementation if the muscle glycogen levels fall below a critical threshold. Although phosphocreatine resynthesis is most important when sprinting, rather than glycogen availability, in order to maintain optimal performance an athlete may need some glycogen to maintain anaerobic capacity, recover between sprints, and produce the same level of power repeatedly.

It is our hypotheses that 1) Honey and PowerAde will both improve anaerobic performance, specifically peak power, mean power, and fatigue index over the placebo, 2) honey will perform just as well if not better than PowerAde with regards to peak power, mean power, and fatigue index, 3) scores on the RPE will be lower with use of honey and PowerAde when compared to the placebo, and 4) scores on the RPE will be the same if not lower with use of honey over PowerAde.

In addition, our research question is: Does ingestion of honey cause gastrointestinal distress before an intense bout of anaerobic activity?

Outcome. A pre-exercise supplement that is effective in improving performance, but doesn't cause adverse effects in the GI tract is beneficial for athletes Although a liquid supplement is convenient for most athletes, the fluid can often lead to GI distress. It is anticipated that the sugar found naturally in honey will improve anaerobic performance without causing GI distress. This would give athletes a natural and cheaper alternative to the currently popular sports drinks and gels that are used prior to exercise. Another advantage of collegiate athletes using honey, it is not a substance that is banned by the NCAA.

Describe your subjects. Approximately 20 male soccer players (ages 18-22 years old) at Georgia Southern will be recruited for this study. Subjects will be current members of the 2011-2012 soccer team and will be currently participating in postseason training during testing. All Georgia Southern University athletes are administered and have passed a physical through the department of intercollegiate athletics in order to participate in collegiate competition. All athletes' personal medical records are kept confidential by the Georgia Southern Athletic Training Staff. At no time will details of any injury incurred by an athlete that is to participate in this study be disclosed to the research team. The research team will only be informed of an athlete's eligibility to participate in this study by the team's certified athletic trainer. Any athletes that have been deemed unfit to participate by the team's athletic trainer will be excluded from the study. Participants will be asked if they have any food allergies or intolerances prior to the study. Participants that report having a food allergy or food intolerance to any of the substances in the supplements (glucose, fructose, sugar substitutes), will be excluded from the study. There will be no compensation for participating.

Methodology (Procedures). Subjects will be recruited during a practice session where they will be notified of the study and asked to complete an informed consent form. They will be asked if they have any food allergies or food intolerances to certain foods/substances to ensure safety of ingestion of the supplements (please see attached demographics). Subjects will then be randomly assigned to one of three groups (Group 1 – honey, PowerAde, then placebo, Group 2 – PowerAde, placebo, then honey, and Group 3 – placebo, honey, then PowerAde) and weighed in on a calibrated scale. Later that week, a specific day will be chosen to complete a practice run through of the test to ensure there is no effect in performance due to unfamiliarity of the repeated anaerobic sprint test (RAST). Timing gates are expected to be used, but a double stopwatch method may be utilized, if necessary.

During the second week, three specific days will be selected for subjects to be tested. Group 1 will test on the first day, Group 2 the following day, and Group 3 the next day. The night before their assigned testing day, subjects will be asked to record their last meal prior to their overnight fast. On their designated day, subjects will report to practice after an overnight fast (nothing to eat or drink, other than water, for 10 hours). In addition, they will also be asked to refrain from exercise 10 hours prior to testing. Subjects will turn in their food record from the night before and this will be kept on file in order to remind them what they will need to eat the night before their next trial. Group 1 will then receive the honey and water mixture, group 2 will receive the PowerAde, and group 3 will receive the placebo on their respective days. The subjects will be blinded in terms of what they are receiving. Subjects will be staggered about five minutes apart when they receive their treatment so there will be only two subjects testing at a time. After ingestion, subjects will do a brief (~15 minutes) warm-up. Once the warm up is complete, testing will begin. The two subjects testing will run in opposite directions to avoid any effect on performance due to competitiveness. Sprint times and total time to complete will be recorded. When testing is finished, subjects will complete the RPE and will be asked the qualitative survey regarding GI symptoms. Subjects will then be reminded that they will be performing the test again in exactly one week. Snacks will be provided following the RAST.

During the third week, subjects will have their pre-test meal returned to them, so they know what to eat the night before and be reminded via text and email to remember to fast and refrain from exercise 10 hours prior to test day. On testing day, with groups on their respective days, will follow a crossover design and receive a different treatment: Group 1 will receive PowerAde, Group 2 will receive the placebo, and Group 3 will receive the honey. Tests will be conducted and times will be recorded the same way it was done the previous week. RPE scores will be collected and qualitative surveys given, followed by snacks for the subjects.

During the fourth week, subjects will return to do their final test. The same procedure will be followed for this testing day. Again, subjects will be asked to come in a fasted state. In this trial, subjects will receive the final treatment: Group 1 will receive the placebo, Group 2 will receive the honey, and Group 3 will receive the PowerAde. Tests will be conducted and times will be recorded. When testing is complete, RPEs will be scored, surveys will be conducted and subjects will be given snacks. At the end of the week when all subjects have completed their last test, they will be debriefed. Researchers will inform each participant what supplements were used in the study, what week they received each supplement, and how each supplement affected their performance and digestive (GI) system

Group Assignment

Group Number	Week One Supplement	Week Two Supplement	Week Three Supplement
1	Honey	PowerAde	Placebo
2	PowerAde	Placebo	Honey
3	Placebo	Honey	PowerAde

*Note: A certified Georgia Southern athletic trainer will be present at all practices and testing sessions. All trainers are certified in first aid and CPR.

Supplements: All subjects will receive each type of supplement, but at different times during the study period. The supplements include: 1) The Placebo: 9.5 ounces of a sugar free, no calorie water (Fruit 2-O, Sunny Delight Beverages, Co. ©2009 Veryfine Products, Inc. Lemon flavor); 2) 9.5 ounces of a sports drink (Mountain Berry Blast PowerAde, Coca Cola © 2011), and 3) 20 grams (1 Tablespoon) of a natural honey (Sasserfrass Hill Bee Farm in Augusta, Georgia) mixed with 3 ounces of water. Supplements will be pre-measured and mixed in plastic cups prior to distribution at practice.

***Repeated Anaerobic Sprint Test (RAST)*:** This test will be used to measure anaerobic capacity. Marker cones and lines will be placed 35 meters apart to show distance to be completed. Two additional cones will be placed five meters beyond both of the initial cones. A double stopwatch method or timing gates placed at the marker cones on either side will be utilized. A stopwatch will also be running for the entire time of the test to keep record of the rest periods. The single sprint time will be recorded and the athlete uses the five meter cone to slow down and return to the 35 meter finishing line. The next sprint is in the opposite direction and begins ten seconds after the previous sprint ended. This pattern will be repeated until six sprints have been completed. Participants' sprint times will be examined and scored using maximum and minimum power and a fatigue index. Maximum and minimum power is calculated by multiplying the subject's weight by the distance squared (35x35 = 1225) divided by the fastest (or slowest) sprint time. Once these values are determined, the fatigue index is found by subtracting the minimum power from the maximum power and dividing the result by the total time for the six sprints (Zagatto, Beck, & Gobatto, 2008).

Maximum Power, Average Power, and Fatigue Index: Participants' sprint times will be examined and scored using maximum and minimum power and a fatigue index. Maximum and minimum power is calculated by multiplying the subject's weight by the distance squared (35x35 = 1225) divided by the fastest (or slowest) sprint time. Once these values are determined, the fatigue index is found by subtracting the minimum power from the maximum power and dividing the result by the total time for the six sprints. Average power will be determined by multiplying the subject's weight by the distance squared (35x35 = 1225) and dividing by each sprint time. Then add all of the powers together and divide by six ((Zagatto, Beck, & Gobatto, 2008).

***Borg's 6-20 RPE scale*:** This scale is used to measure perceived exertion in a subject's bout of physical activity. It is a subjective rating system where a subject records how they feel after an athletic activity. The scale ranges from 6-20, with 6 being extremely light and 20 being the most strenuous ever done; and has a direct correlation to heart rate. It is said that if you multiply the chosen number by 100 you should have the approximate heart rate for the athlete. The validity of this test is criterion-related with the correlation to heart rate and the reliability falls at 0.8, (Psycharakis, 2010).

***Qualitative Survey*:** These questions will be used to assess whether the subjects experience any GI discomfort during the test and if they did experience symptoms, the severity of them. Please see attached document.

Data Analysis – Statistical significance will be set at $P < .05$. Data will be analyzed using multiple one-way ANOVA with repeated measures tests. All statistics will be calculated with SPSS 19.00 (SPSS Inc. Chicago, IL).

Special Conditions:

Risk. The risks associated with anaerobic fitness testing are minimal in a healthy population, but may include muscle soreness and possible strained muscle, twisted knee or ankle during the fitness test. Risks will be minimized by using proper warm up and flexibility protocols. Medical care will be available in the event of injury by a Georgia Southern University athletic trainer, but neither financial compensation nor free medical treatment will be provided. Georgia Southern University and the researchers of this study will not be held accountable for any injury that may occur during the time of testing. Additional discomforts that may occur in some individuals include bloating, stomach cramps, nausea, or diarrhea as a result of carbohydrate intake and physical activity. The taste of the supplements may be less appealing to some.

Deception. Subjects will be blinded as to which treatment they are receiving at which time. This will add more reliability and validity to the study. At the completion of the study, all participants will be debriefed. Researchers will inform each participant what supplements were used in the study, what week they received each supplement, and how each supplement affected their performance and digestive (GI) system.

Medical procedures. No medical procedures will be used in this study. (See attached document)