THE CORRELATION OF DIET DURING THE ABSORPTIVE PERIOD AND PERFORMANCE IN DIVISION 3 COLLEGE SOCCER PLAYERS

A Report of a Senior Study

by

Kai Miettinen

Major: Biology

Maryville College

Spring, 2020

Date approved April 23, 2020, by ______________________

Faculty Supervisor

Date approved ______________, by ______________________

Division Chair

ABSTRACT

The aim of this study was to determine whether or not carbohydrate consumption in the absorptive period had any effect on performance in Division 3 athletes in home verses away games and games verses practices. All 22 participants were Division 3 soccer players. The participants diets were monitored throughout the entire soccer season. In addition, their distance ran, work rate, and hard running were kept track of from the Game Traka technology system in all practices and home/away games. After analyzing all the data, it was determined that the distance ran in home vs away games and games vs practices, their showed no significance (p=0.0701; p=0.4863). Work rate was significantly greater at home games when compared to away (p=0.0352), likely because of restricted meal options when away. However, there was no significance in work rate when comparing games vs practices (p=0.3019). Lastly, hard running showed significance at home games compared to away games (p=0.0423); however, there was no significance shown when comparing games vs practices (p=0.1787). Based on this study, it is important for athletes and their coaches to keep track of the players diets and maybe even have them all keep track of it to see if it is affecting their performance. This could be done by each player on the team being assigned a partner and before each training session or game they record what each other ate prior to that event. Then, coaches could be given this information and compare it to the performance of each player at the end of the season. For future studies, it would be interesting to look into whether or not carbohydrates with the addition of a protein beverage would have any significant impact on performance in athletes.

ACKNOWLEDGEMENTS

I would like to acknowledge the people who played such a pivotal role in my thesis through the last year. First off, I would like to thank and acknowledge Dr. Drew Crain who is my academic advisor. Thank you for your hard work and support throughout this thesis process. Secondly, I would like to acknowledge Pepe Fernandez who is the Maryville College Men's and Women's soccer coach. Thank you for your support and allowing me to use your team in my study. Lastly, I would like to acknowledge the Maryville College Men's soccer team. Thank you, guys, for your cooperation and being willing to take part in my thesis this last year.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The correlation between food consumption and performance in sports is a topic of great research interest. One specific type of food people normally associate with sports performance is carbohydrates, and carbohydrates have become a prominent choice for most athletes prior to athletic events. A major goal of training to improve performance of prolonged, continuous endurance events is to promote a range of physiological and metabolic adaptations that permit an athlete to work at both higher absolute and relative power outputs/speeds and delay the onset of fatigue; to meet these goals, competitive endurance athletes undertake a prodigious volume of training, with a large portion performed at intensities that are highly dependent on carbohydrate based foods to sustain rates of muscle energy production (Hawley, 2015). The consumption of carbohydrates immediately before and during exercise represents an effective strategy to provide an exogenous fuel source to the muscle and central nervous system (Burke, 2011). Carbohydrates are said to be a factor that makes an athlete perform at a more consistent and higher level than the people who do not eat much before competing.

Adenosine triphosphate, also known as ATP, plays a major role in providing our bodies cells with fuel and is a great source of energy for our body's muscles. ATP generation of carbohydrates, fats, and proteins is something all serious athletes take into account when eating days/hours prior to performance. Despite renewed interest in high-fat, low carbohydrate diets for endurance sport, fat-rich diets do not improve training capacity or performance, but directly impair rates of glycogenolysis and energy flux, limiting high-intensity ATP production (Hawley, 2015). Experts have agreed that protein needs for performance are likely greater than they used to be in the past, particularly for strength training exercise, and that dietary fats could sustain an active person through low-intensity training workout, but current research still points to carbohydrate as an indispensable energy source for high-intensity performance (Kanter, 2018). Protein needs for performance are likely greater than they used to be because athletes need to be able to repair muscle that has been broken down during a period of exercise and to also help with the storage of carbohydrates. Although dietary protein and fat can provide necessary energy to perform physical activity, carbohydrate is the substrate most efficiently metabolized by the body and the only macronutrient that can break down rapidly enough to provide energy during periods of high-intensity exercise when fast-twitch muscle fibers are primarily relied upon (Kanter, 2018). With this being said, protein and some fat consumption prior to exercise is still beneficial to performance to some extent; however, carbohydrates are more commonly used prior to high-intensity exercise because of how it is able to maximize the use of glycogen. Table 1 presents data from multiple studies in multiple sports and how different carbohydrates effected performance.

Table 1. 10 different studies looking at carbohydrates and how it affects performance in different athletic activities.

Carb. Type	Sport	Findings	Citation
7% carb drink or 0 carb placebo	Soccer	Agility were not different between the carbs and placebo trials; however, fatigue was shown to affect the placebo group faster than the carb group	Goedecke et al. 2013.
Light meal 2-4 prior to match; at halftime players ingested 5 ml/kg of either artificial sweetened placebo or a 6.9% glucose polymer (GP)	Soccer	In this study, after taking carbs, all of the tests (passes, tackles, headers/dribbling shots) were not affected by the people who took carbs, but ball control; however, was improved.	Zeederberg et al. 1996.
Participants ingested either an artificially sweetened placebo twice or carbs with 7.5% maltodextrin	Soccer	The six-agility tests that were ran showed no significant different between the two placebos, but there was a 2.0% increase in performance with the people given carbs	Currell et al. 2009.
Diets of players were recorded and were presented 2 days leading up to the experiment, which then the mean	Soccer	After pre- and post-exercise results came in, it showed a 3 ± 12% decrease in performance in the carbohydrate-electrolyte trial, but a 14 ± 24% decrease in	Ali et al. 2009.

energy and carbohydrate intake were calculated		the placebo trial, although the results were not statistically significant (P=0.07)	
Participants fasted 12h prior to exercise and then were given a sports drink that contained 6.4% Carbohydrates during testing	VO_2 Testing; Exercise Activities	This study showed that carb ingestion during prolonged high-intensity exercise appeared to show an enhanced perceived activation profile that may impact upon take persistence and performance. Placebo showed lower less significant results in the last 30 min of exercising compared to the carbs	Backhouse et al. 2007.
Not specified; Just fed Carbohydrates	Strenuous exercise; Cycling	Participants showed an increase in plasma glucose (mM), Carbohydrate oxidation (g/min), and muscle glycogen (mmoles g.u./kg) when carbohydrates were taken compared to the placebo, which were participants that did not take carbohydrates	Coyle et al. 1985.
Not specified; Just fed Carbohydrates	Cycling and Running	ATP levels were not significantly increased with carb ingestion; however, phosphocreatine levels were increase when carbs were administered. Also, carbs provided protection from disrupted cell	Karelis et al. 2010.

		homeostasis, which was said to possibly translate to better muscle function and an increase in performance during exercise	
Normal Carb diet and High Carb diet	Cycling	After carbo-loading, all except one of the subjects went faster during the last hour of the trial compared to the normal carb subjects.	Rauch et al. 1995.
Solid-carb/ Liquid-carb/ pre-exercise meal plus solid carb	High intensity exercise	The solid, liquid and pre-exercise carbohydrate subjects all around performed better compared to that of the placebo.	Neufer et al. 1987.
Low GI-High carb meals 2 hrs before testing and high-GI high carb meals	Cycling and VO_2 max testing	This study looked at respiratory exchange ratio, total carb oxidation, and ingested carb oxidation. The respiratory exchange results showed that HGI and LGI was just a little higher than that of the placebo, and for the total carb oxidation and ingested carb oxidation, there was not a significant difference in exercise over time compared to that of the placebo	Burke et al. 1999.

Intermittent sports are diverse in their rules and regulations but similar in the pattern of play; that is, intermittent high-intensity movements and the execution of sport-specific skills over a prolonged period of time (1-2 hours) (Baker et al., 2015). Intermittent sports include field hockey, basketball, American football, rugby, tennis, and soccer. Most of these sports are team sports, which have moderate to long-duration exercise. When looking at this physiologically, team sports are characterized by their moderate-to-long distances covered by players during a game/match, but also the variable activity pattern (e.g. in excess of 800 activity changes per football match, including walking, jogging, cruising, sprinting, backing, jumping, tackling and heading) (Mujika & Burke, 2010). The activity pattern of repeated sprints with little recovery duration in-between determines to a great extent the physiological requirements of intermittent team sports, and some these requirements include not only a high aerobic capacity, but also a high glycolytic capacity (Mujika & Burke, 2010).

Glycogen is stored in the muscles of the body and depending on the amount of carbohydrate that an athlete depends on how much stored glycogen he/she has. This is important to note because carbohydrates allow endurance athletes to last longer during exercise. For example, marathon runners consuming high-carbohydrate diets rather than a mixed diet or a high-fat diet have more endurance because of the amount of glycogen that is stored in their muscles (See Table 2).

Table 2. Showing marathon athletes endurance to the point of exhaustion (min) during a race based on their diets prior to racing (Hall & Guyton, pg. 1086, 2011).

Diet	Minutes
High-Carbohydrate Diet	240
Mixed Diet	120
High-Fat Diet	85

Performance during intermittent sports is dependent upon a combination of anaerobic and aerobic energy systems, both of which rely on muscle glycogen and/or blood glucose as an important substrate for energy (Baker et al., 2015). When looking at the sport of soccer specifically, muscle glycogen is reduced by 40% to 90% during a game and is probably the most critical substrate for energy production, and fatigue toward the end of a game could be related to the depletion of glycogen in some muscle fibers (Bangsbo et al., 2007). Fatigue during prolonged exercise is often associated with muscle glycogen depletion and reduced blood glucose concentration and, therefore, high pre-exercise muscle and liver glycogen concentration are said to be essential for optimal performance, although none of these factors alone seem to limit prolonged exercise (Jeukendrup, 2011).

Fatigue is a major reason why athletes can experience a decrease in performance, and there are two different types of fatigue an athlete can experience during an intermittent sport. One of the types is considered temporary fatigue, which an athlete would experience during a game and the other type a more permanent fatigue at the end of a game. One study on temporary fatigue observed muscle lactate and pH during a soccer game and saw that muscle lactate rose fourfold compared with resting values after intense periods of the game (Mohr et al., 2011). In addition, researchers found a weak but significant correlation (r=0.41) between muscle lactate and decreased sprinting performance after an intense period, which could suggest that temporary fatigue during a game may be related to high muscle lactate concentrations and/or muscle acidosis, since it has been demonstrated in *vitro* that high lactate and low pH impair muscle performance during intense contractions (Mohr et al., 2011). Avoiding fatigue can play an important role in performance because starting to fatigue early in any kind of sport may impact your performance significantly. Ingestion of carbohydrates is very popular in regard to sports because carbohydrates seem to reduce the onset of fatigue throughout intermittent sports. A recent study says, that the current guidelines for athletes that compete in intermittent sports recommend the ingestion of carbohydrates at a rate of 30-60 g/h during >1h of training and competition so that fuel is provided to the muscle and central nervous system to delay fatigue as well as for the potential of non-metabolic central effects to reward and motivation (Baker et al., 2015). In another study, researchers say that the consumption of a high carbohydrate diet in the days or hours leading up to exercise can have positive effects on exercise performance, but it is suggested that athletes consume carbohydrates 30-60 min before adversely affect performance because glucose ingestion in the hour before exercise can result in hyperglycemia and hyperinsulinemia, which is usually followed by an extreme decline in blood glucose after the onset of exercise (Jeukendrup, 2011).

Table 3 shows two different types of athletes and their requirements between carbohydrates, fats and proteins (Ultra-endurance means consecutive hours/ days of exercise).

Table 3. Recommended portions of three macronutrients during endurance and ultra-endurance exercises.

Type of Athlete	Carbohydrates	Fats	Proteins
Endurance	6-10 g/kg of body weight	Not recommended before exercise	1.2.-1.4 g/kg body weight
Ultra-endurance	6-10 g/kg of body weight	Not recommended before exercise	1.2-1.7 g/kg body weight

Numerous studies have focused on carbohydrate ingestion prior or during some kind of physical activity (see Table 1). The first four studies shown in Table 1, look at carbohydrates and how it affects performance in soccer players specifically. In one study, researchers studied 22 average male soccer players and they completed two randomized trials, separated by 7 days (Goedecke et al., 2013). During the trials, participants ingested in random order either a commercially available 7% carbohydrate sports drink or a placebo beverage (0% carbohydrates) of similar taste and electrolyte concentration; in addition, all trials were done at the same time of day, to avoid any diurnal effect on the results (Goedecke et al., 2013). During each trial, the participants completed a previously validated simulated soccer match, followed by a run to fatigue (LIST) and a modified Illinois agility test (Goedecke et al., 2013). Prior to each trial testing the participants were put through a serious of stretching and running warm-ups for approximately 15 minutes. When looking at the results regarding the Rating of Perceived Exertion (RPE) from time to fatigue, the players that administers the 7% carbohydrate drink had the same RPE as the placebo group except for exercise session 4 (Goedecke et al., 2013). However, when looking at the results regarding changes in agility and time to fatigue, the participants showed no difference in agility between the 7% carbohydrate group and the placebo group, but in the time to fatigue test, the players that administered the 7% carbohydrate drink lasted longer and did not fatigue as fast as the players with the placebo (Goedecke et al., 2013). This data does not necessarily show that carbohydrate administration improves performance, but rather it decreases your chances of getting fatigued, which could lead to better performance. In all of the other studies on soccer performance, there seem to be no significant effect on carbohydrates and performance except for the studies done by Zeederberg et al. (1996) and Currell et al. (2009).

In the study done by Zeederberg et al., they found that carbohydrates did not impact the performance of passes, tackles, headers/dribbling shots; however, they did have an impact on ball control. In the study done by Currell et al., researchers found that the six-agility tests that were ran showed no significant different between the two placebos, but there was a 2.0% increase in performance with the people given carbohydrates. Furthermore, the other studies looked at carbohydrates and how it impacted performance in cycling, VO_{2max} testing, and high intensity exercise. The articles involving cycling or prolonged exercise had participants consuming the carbohydrates during the exercise rather than before. In most all of these studies, the results showed that participants that took carbohydrates did perform better, and for a longer period of time without fatigue compared to the participants that did not have any carbohydrate intake (controls).

This aim of the present study is to track the diet of division 3 soccer players in the absorptive period (4 hours prior) before games/practices using a unique system called the "game traka". The game traka system is a tracking device each player wears while playing, and it tracks their performance throughout the games or practices. Some specific performance statistics that I will be looking at will be top speed, intensity, hard-running, and distance traveled. Using these statistics, I will be comparing the players based off of their diet prior to each game/practice and seeing if it correlates with performance. Based on previous studies (see Table 1), it is expected that the players who consume carbohydrates prior to activity will perform better than the people who did not eat carbohydrates. This is because fatigue is not expected to affect the players that took carbohydrates as early on in activity as it would for players with no carbohydrates prior to exercise.

CHAPTER II

MATERIALS AND METHODS

Subjects

The participants that took part in this study are division III men soccer players at Maryville College in Maryville, TN. The athletes were provided with a specific code, so that their names were left confidential, and they were also given a consent form prior to the start of the study, so that they knew what the study was about and their complete role in the study. A total of twenty athletes were used in this study, with the athletes ages ranging between 18 and 24 years of age. All athletes previously had some type of soccer history before competing at the Division III level. The participants weighed between 59 kg to 86 kg and their height ranged between 1.7 meters to 1.9 meters.

Measurements

"Game Traka" technology was used to track performance data during practices and games for all player. This worn device uses specific sensors that players placed into a little slot on the back of a sports bra that they wore during matches/practice. Once a match or practice was over athletes placed their trackers into this black plastic briefcase-looking box, which charged the trackers and allowed our coaching staff to upload all of the data from each player onto the application/website. These sensors track a substantial amount of different varieties of data. For example, it tracks distance traveled during a match/practice, hard-running, top speed, total time spent, sprint efforts, work rate, impacts and intensity. The trackers also track many other statistics. For this study specifically, the statistical data that was collected and recorded was distance travelled, hard running, and work rate were used comparing the athletes. In addition, athletes were asked prior to each match/practice what foods they ate four hours leading up to the matches or practices. The participants were not asked to eat anything specific throughout the study. This data was then recorded on safe and secure device. Participants completed IRB approved questionnaires after every performance (see Appendix 1).

After the matches and practices, data from each of the categories mentioned above were recorded and put with the data from what that athlete ate leading up to the match or practice. All data was recorded in the Fall Semester of 2019 in the months September- October. Practices were 5-6 times a week depending on the match schedules, and most weeks consisted of 1-2 matches a week. On practices that were a day or two before the matches and a day after the matches, the data was not recorded because of the practices mainly consisted of walk throughs and recovery sessions. There were some complications throughout the study in regard to getting data for some of the players throughout practices and matches because there were injuries/school related instances that caused some of the participants to not have data in some of the matches or practices.

Statistics

The data was analyzed using Microsoft Excel 2019. All of the data was rounded to four decimal places to make everything consistent. All data was collected throughout the Fall 2019 semester. Throughout the Fall soccer season, from September to November, the food ate by the participants was recorded in an Excel spreadsheet in calories along with the distance, work rate and hard running that each participant had according to the Game Traka device. After all the data was collected, it was analyzed, and the calories ate was narrowed down to the amount of carbohydrates each person ate four hours prior to the games/practices. The slope, p-value, and R^2 was then calculated for the carbohydrates compared to the distance, carbohydrates compared to work rate, and carbohydrates compared to hard running. The R^2 was found by creating a scattered plot for each statistic compared to carbohydrates, the p-value was found by using regression analysis, and slope was calculated using slope formula on Excel. After all this data was finished and analyzed, it was determined to take all of the slopes, average them, and compare them to home vs away games and games vs practices. All this data was put into a big table to show all this data summarized (see Table 4). After getting the average slopes, bar graphs were made to show the comparison between carbohydrates and distance, work rate, and hard running (see Figure 1A-3B). To find the p-values of the bar graphs and the significance, a t-test: two-sample assuming unequal variances was conducted.

CHAPTER III

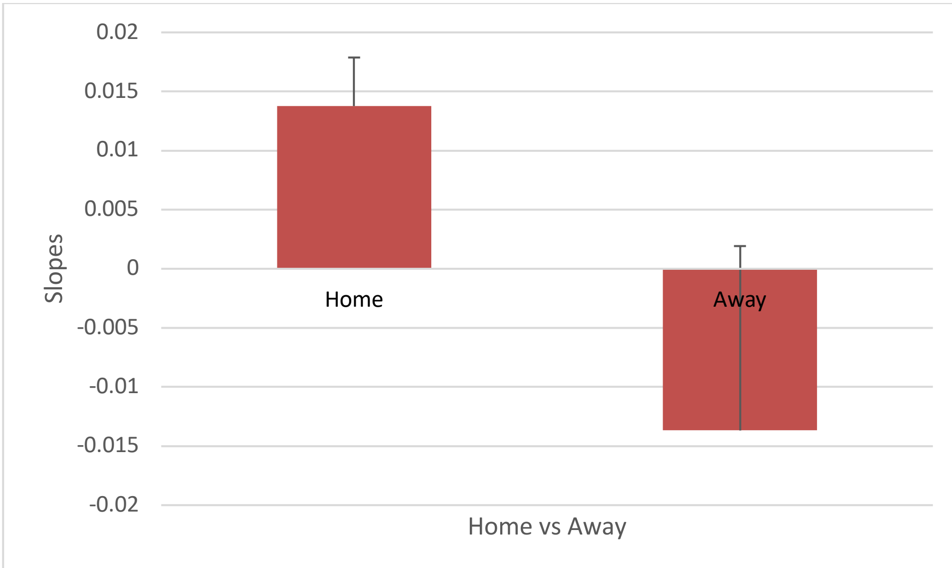
RESULTS

After analyzing all the data, it was determined that the best way to summarize it all was to create a table showing the slopes, p-values, and R^2 of all data points that are of interest, which include, distance, work rate and hard running compared to the amount of carbohydrates consumed by all participants involved (see Table 4).

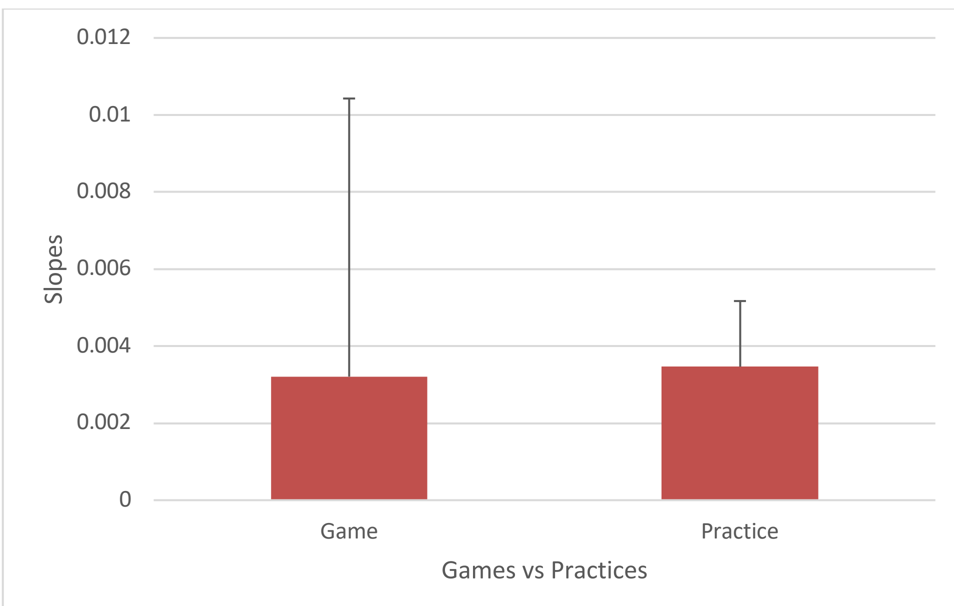
A comparison of the mean slopes of home games vs away games and games vs practices were made. The mean slopes were first taken for distance ran when comparing home vs away games and games vs practices. First, when looking at the comparison between distance ran in home vs away games, it showed there was no significance (p-value: 0.0701) (see Figure 1A). In addition, when looking at the comparison between distance ran in games vs practices, it also showed there was no significance (p-value: 0.4863; see Figure 1B). Second, when comparing the participants work rate in home vs away games, there was significance shown (p-value: 0.0352; see Figure 2A). However, when comparing the participants work rate in games vs practices, there is no significance (p-value: 0.3019) (see Figure 2B). Finally, when comparing the participants hard running in home vs away games, there is significance (p-value: 0.0423; see Figure 3A). In contrast, when looking at the comparison of the participants hard running in games vs practices, there was no significance (p-value:0.1787; see Figure 3B).

Table 4. The calculated slopes, p-values, and R^2 of distance ran, work rate, and hard running compared to the amount of carbohydrates consumed.

Date	Game/Practice	Distance: Slope, P-value, R^2	Work Rate: Slope, P-value, R^2	Hard Running: Slope, P-value, R^2
Sept. 20	Game- Home	0.006 (P=0.682, R^2=0.009)	0.063 (P=0.684, R^2=0.009)	0.133 (P=0.953, R^2=0.000)
Sept. 28	Game- Home	0.011 (P=0.136, R^2=0.108)	0.111 (P=0.227, R^2=0.072)	4.242 (P=0.124, R^2=0.114)
Oct. 5	Game- Home	0.018 (P=0.023, R^2=0.255)	0.216 (P=0.030, R^2=0.236)	1.708 (P=0.312, R^2=0.057)
Oct. 6	Game- Home	0.024 (P=0.027, R^2=0.258)	0.217 (P=0.057, R^2=0.198)	3.282 (P=0.066, R^2=0.185)
Oct. 9	Game- Home	0.008 (P=0.427, R^2=0.036)	1.906 (P=0.333, R^2=0.052)	0.797 (P=0.678, R^2=0.010)
Oct. 19	Game- Home	0.001 (P=0.967, R^2=0.000)	0.042 (P=0.841, R^2-0.003)	2.578 (P=0.537. R^2=0.028)
Oct. 20	Game- Home	0.036 (P=0.015, R^2=0.338)	0.417 (P=0.011, R^2=0.358)	4.713 (P=0.010, R^2=0.366)
Nov. 2	Game- Home	0.007 (P=0.671, R^2=0.012)	0.082 (P=0.633, R^2=0.015)	0.002 (P=0.999, R^2=0.000)
Oct. 2	Game- Away	0.001 (P=0.972, R^2=0.000)	0.007 (P=0.964, R^2=0.000)	-2.126 (P=0.464, R^2=0.030)
Oct. 12	Game- Away	0.008 (P=0.594, R^2=0.017)	0.071 (P=0.638, R^2=0.013)	-0.471 (P=0.844, R^2=0.002)
Oct. 25	Game- Away	0.015 (P=0.064, R^2=0.239)	0.149 (P=0.031, R^2=0.309)	2.425 (P=0.178, R^2=0.135)
Oct. 26	Game- Away	-0.072 (P=0.165, R^2=0.124)	-0.813 (P=0.163, R^2=0.125)	-12.685 (P=0.088, R^2=0.181)
Sept. 24	Game- Away	-0.02 (P=0.467, R^2=0.028)	-0.350 (P=0.061, R^2=0.061)	-9.709 (P=0.062, R^2=0.171)
Sept. 23	Practice	0.002 (P=0.228, R^2=0.084)	0.104 (P=0.106, R^2=0.146)	0.048 (P=0.825, R^2=0.003)
Sept. 25	Practice	-0.001 (P=0.575, R^2=0.018)	-0.028 (P=0.520, R^2=0.023)	0.113 (P=0.780, R^2=0.005)
Sept. 26	Practice	0.001 (P=0.703, R^2=0.008)	0.048 (P=0.449, R^2=0.032)	1.738 (P=0.204, R^2=0.088)
Oct. 15	Practice	0.012 (P=0.036, R^2=0.317)	0.139 (P=0.051, R^2=0.281)	3.014 (P=0.252, R^2=0.108)
Oct. 17	Practice	-0.000 (P=0.929, R^2=0.001)	0.026 (P=0.668, R^2=0.028)	-0.927 (P=0.332, R^2=0.134)
Oct. 23	Practice	0.010 (P=0.197, R^2=0.147)	0.262 (P=0.199, R^2=0.145)	0.255 (P=0.848, R^2=0.004)
Oct. 28	Practice	-0.004 (P=0.246, R^2=0.102)	-0.078 (P=0.277, R^2=0.090)	0.532 (P=0.454, R^2=0.044)
Oct. 29	Practice	0.005 (P=0.052, R^2=0.244)	0.060 (P=0.071, R^2=0.214)	3.485 (P=0.020, R^2=0.329)
Nov. 5	Practice	0.006 (P=0.077, R^2=0.193)	0.105 (P=0.137, R^2=0.342)	1.219 (P=0.111, R^2=0.161)

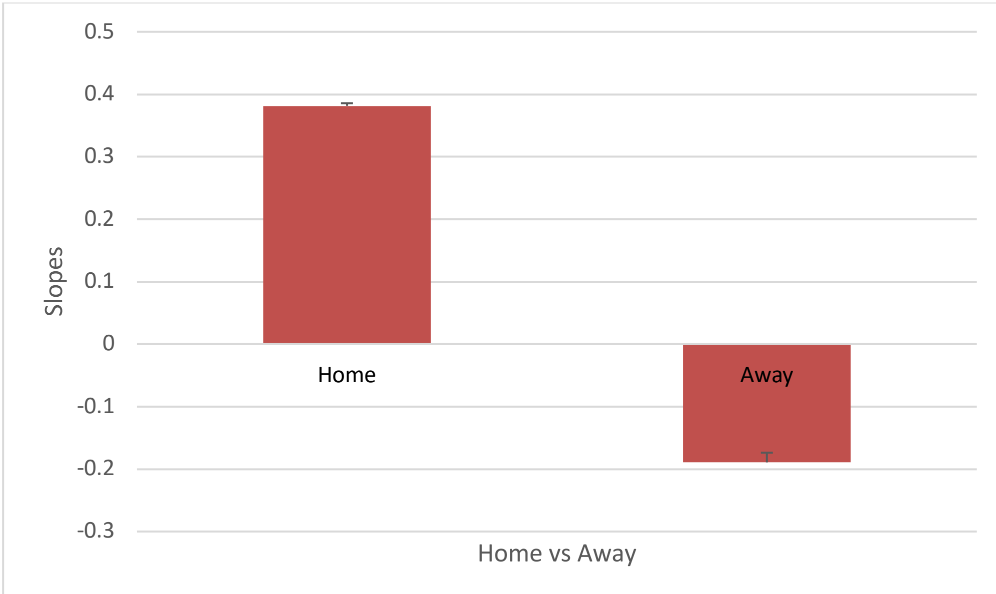


A.

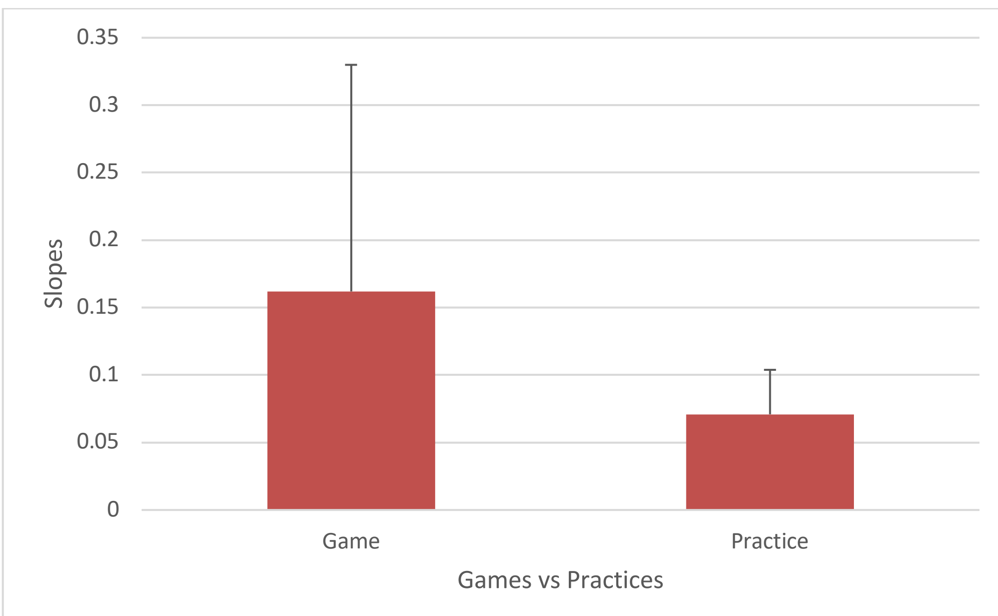


B.

Figure 1. A.) Mean slopes (+1SE) of distance ran compared to amount of carbohydrates consumed in home vs away games (p=0.070). **B.)** Mean slopes (+1SE) of distance ran compared to the amount of carbohydrates consumed in games vs practices (p=0.486).

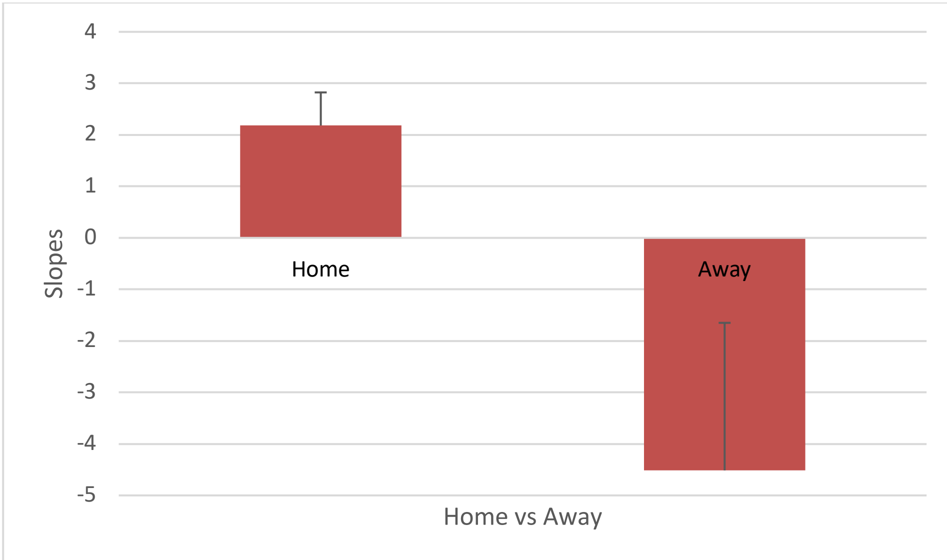


A.

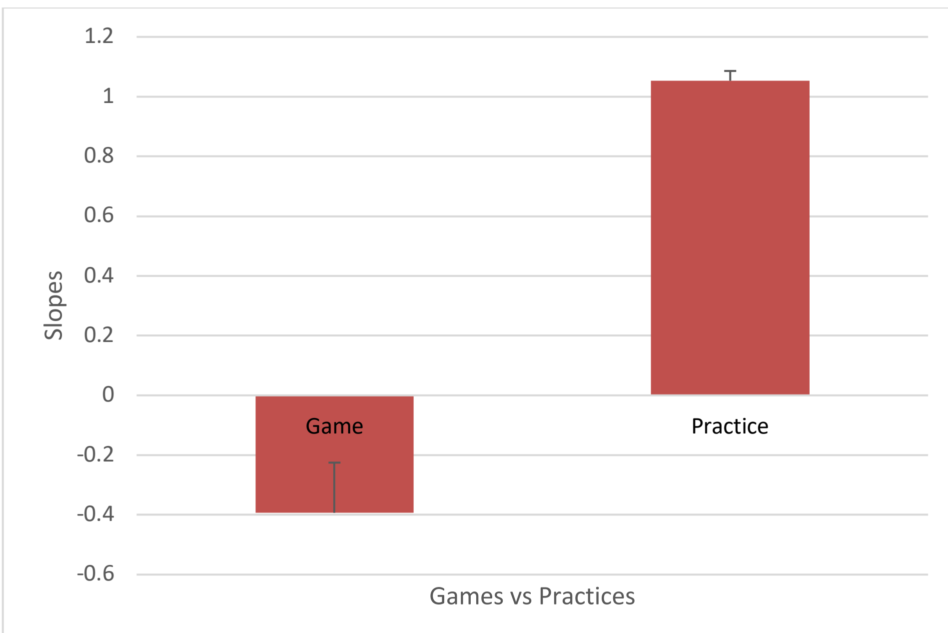


B.

Figure 2. A.) Mean slopes (+1SE) of work rate compared to amount of carbohydrates consumed in home games vs away games (p=0.035). **B.)** Mean slopes (+1SE) of work rate compared to the amount of carbohydrates consumed in games vs practices (p=0.302).



A.



B.

Figure 3. A.) Mean slopes (+1SE) of hard running compared to the amount of carbohydrates consumed in home games vs away games (p=0.042). **B.)** Mean slopes (+1SE) of hard running compared to the amount of carbohydrates consumed in games vs practices (p=0.179).

CHAPTER IV

DISCUSSION

The purpose of this study was to determine if carbohydrate consumption prior to an athletic performance had any effect on distance ran, work rate, or hard running in division 3 soccer players when comparing home games vs away games and games vs practices. After collecting and analyzing data, the results showed that carbohydrate intake significantly increased work rate and hard running at games when compared to practices. This is likely due to the fact that during home games the participants ate all different types of foods, while at away games, the participants all ate at the same place prior to the games. For example, if the team went to a Subway restaurant, then everyone had to eat something from that Subway, and there was consistent carbohydrate consumption.

There was no difference in distance ran in home games vs away games. In addition, games and practices did not differ in distance ran, work rate and hard running. The cause of this could due to many different reasons. One for instance, could be the fact that there were more games than practices in this experiment and that the intensity in a game compared to a practice is quite different. Another cause could be due to the small sample size. There were 22 participants in this study, and during a soccer game only 11 people are able to play, which means the starters are going to get the majority of the minutes, which causes the other participants to not get as much playing time therefore limiting there statistics of distance ran, work rate and hard running.

A similar study performed by Chryssanthopoulos and Williams (1997), looked at giving participants a pre-exercise carbohydrate meal before exercise and a carbohydrate-electrolyte solution during exercise to see if improved their endurance running capacity compared to just a carbohydrate-electrolyte solution by itself. In this study, there were ten men who performed three treadmill runs at 70% VO_2max until they hit exhaustion. One run consisted of both the carbohydrate meal and the carbohydrate-electrolyte solution, the second run consisted of just the carbohydrate-electrolyte solution and a liquid placebo, and the third run consisted of a liquid placebo 3 hours before and a liquid placebo during the run. The results showed that endurance or exercise time was longer in the participants who had the carbohydrate meal 3 hours prior and the carbohydrate-electrolyte solution during the run compared to just the carbohydrate-electrolyte solution and the liquid placebo. This is interesting because the carbohydrates three hours prior and the electrolyte solution showed to increase the endurance and exercise time of the participants, which relates to this study because the only significance found in our study was with work rate and hard running. This could mean that maybe consuming some type of carbohydrate-electrolyte solution during the soccer games and practices on top of having a carbohydrate meal 3-4 hours prior could, in fact, make a difference in the endurance of athletes, which could also enhance their performance.

Another study by Carter et al. (2003), examined the effect of carbohydrate supplementation on moderate and high-intensity endurance exercise in a hot environment. The results showed that the participants time to fatigue was significantly greater in participants who had taken carbohydrates compared to the placebo. This could mean that the weather or temperature of each game or practice in our study could have influenced the distance ran, work rate and hard running. Meaning that the participants could have had more carbohydrates on the days that were hot, which could have led them to fatigue a lot slower.

Other studies have looked at caffeine ingestion along with carbohydrate ingestion to see if there is any impact on the performance of athletes. For example, Jacobson et al. 2001, the effect of caffeine co-ingested with either carbohydrates or fats on metabolism and performance in athletes who are endurance trained. The subjects in this study performed a random order of four experimental trial, which consisted of 120 minutes of steady-state ergometer cycling at 70% of maximal O_2 uptake followed by time trials where the subjects completed a certain amount of work as quickly as they could. One hour prior to the trials, subjects were either given carbohydrates, carbohydrates and caffeine, fats, or fats and caffeine. The results showed that the caffeine co-ingested with either carbohydrate or fat meals has no effect on the exercise performance; however, carbohydrates alone did have a positive effect on exercise performance in the time trials compared to fats. It is interesting to see that caffeine had no effect on exercise performance when it was administered with carbohydrates. This is because caffeine is a supplement that people eat to feel more energy and to get their adrenalin going, so when it was paired with the carbohydrates in the study, you would think that it was increase the performance because of the extra energy from the caffeine and the extra endurance from the carbohydrates. Similar to this study by Jacobson, we looked carbohydrates and its effect on performance, which in our study showed some significance when looking at hard running and work rate. This could mean that consuming carbohydrates prior to exercise could decrease your chances of fatiguing faster, which would allow athletes to perform sprints and fast long distance runs more often and more effectively. This can be shown in our study by the significance in the hard running and work rate compared to consuming the carbohydrates.

Recommendations for Division 3 Soccer Coaches and Trainers

Based on this study, it is important for the coaches and other staff members such as trainers of division 3 soccer schools to understand the effects of carbohydrates on their players, and how looking at the foods eaten by them before games or practices can impact on the performance of the players. The results of this study show that the carbohydrates and types of carbohydrates consumed do, in fact, play a key role in some aspects of the players performances. There are some recommendations for Division 3 soccer coaches that could make a positive impact on the performance of their players based on what they eat. One for example being that most coaches will take the whole to team out to the same place to eat lunch/dinner before their games. However, after observing and analyzing data, I would recommend that coaches find some way so that not all players are exposed to the same carbohydrate options. The data suggested that when all players ate at Subway for example, there was a less significant impact on the players performance. This is likely because all players bodies act differently and require certain foods/carbs that best suits them. In a similar study performed by Maughan (1997), he says that it is clear there are some players that need to consume a diet that is lower in carbohydrates than what's normally recommended so they can sustain their performance in training and competition. Perhaps instead of the entire team going to one specific restaurant before the game, the team could have numerous different options to choose from. Another option would be that coaches or staff purchase a variety of different sources of carbohydrate filled foods.

Another recommendation would be to keep or get tracking system technology in your program, but not only to just look at performance. I would recommend having a trainer or someone keep track of the players diets of what they ate 4 hours prior to games/practices throughout the season. This could be done by simply having players write it down and giving it to the coaching staff/trainers or even just typing it into a google spreadsheet before each game or practice. By doing this, coaches could track how healthy players are eating and if what their eating has any effects on their performance. Based on this study, it appears that the amount of carbohydrates eaten 4 hours prior to games and practices did show significant impact on the work rate and hard running performed by players in games/practices. It is important that every team in all sports, not just Division 3 soccer players, keep track of their diets and find what foods and the amount of carbohydrates best suits them, and it should not only be important to the players, but the coaching staff/trainers too.

Future Studies

The question that's raised is, what comes next? What comes next for future research in this area of study on the effects of carbohydrates and performance in athletes? The first studies on this topic were performed in physically active instead of specifically trained individuals and used specific dietary extremes to achieve maximal effect instead of strategic nutritional manipulations that could be more practical in the field for studies (Burke et al., 2011). This means that since the beginning of this research, researchers have come a long way in finding what the best ways are to test specific athletes to help better understand the effects of carbohydrates in their specific sports. Another factor to look at for in future studies is the excess amount of carbohydrates being ingested. There are some recent studies that have shown that glucose, when it has been ingested at high rates, may not enter the systemic circulation at the same high rates (Jeukendrup & Jentjens, 2000). The role of the liver retaining glucose and the role of absorption are still yet to be discovered (Jeukendrup & Jentjens, 2000). This would be something interesting to look at because most people hear about carbohydrate loading, but little has been discovered on the fact of if the body can absorb that much in such short notice. Lastly, furthering research that is looking more in depth into the co-ingestion of carbohydrate and protein beverages could be explored. There is a small but growing number of different studies that have been published regarding improved performance with carbohydrate-protein ingestion during exercise (Saunders, 2007). Despite these studies, there is still some controversy in regard to the nutritional ingestion protocols and the exercise conditions that go along with this (Saunders, 2007). According to Saunders (2007), there is also questions regarding the types of proteins and the amount of proteins that should be included with the carbohydrates.

Summary

With all of this being said, the main purpose of this experiment was reached. There was significance shown that consuming carbohydrates in the absorptive period (3-4 hours) before practice or games does have some effect on performance. Therefore, I would recommend anyone who does any type of sport to consume some type of carbohydrates 3-4 hours before performing their sport, and if you feel it did not help try and tweak it a little and eat a little less or try a carbohydrate solution (drink) to see if that works.

If I was able to perform this study over again, I would try and get a bigger sample size to see if there are any different significances with the data. In addition, I would have liked to of used the girls' soccer team as well to see if there were any differences between woman and men.

APPENDIX 1:

Maryville College Institutional Review Board
OHRP IRB#: IRB00007383
FWA Assurance #: FWA00015150

Principal Researcher: Kai Miettinen

Faculty Supervisor: Drew Crain

Division: Natural Sciences

Title: **Professor**

Protocol# 130919.01

Approval Status: Approved

September 16, 2019

Dear Kai**,**

The Maryville College Institutional Review Board (IRB) has carefully considered your amended proposal referenced above. The proposed procedures afford reasonable protection to the human participants involved and therefore you are granted approval for the study.

Your approval is effective September 16, 2019 and will expire one year from this date. Thereafter, continued approval is contingent upon submission of a progress report that must be reviewed and approved prior to the expiration date. Approval is contingent upon your agreement to obtain informed consent from your participants, to abide by the protocol summarized in the approved IRB application, and to keep appropriate records concerning your participants.

You are required to submit to the Maryville College IRB for review any changes in procedures involving human participants prior to the implementation of such changes.

If you have any questions concerning this approval or regulations governing human participant activities, please contact Dr. Ryan Mickey, Chair of the Maryville College IRB, by e-mail at IRBReview@maryvillecollege.edu.

Sincerely,

Nathan Duncan

Institutional Review Board

502 E. Lamar Alexander Parkway, Maryville, Tennessee 37804-5907
Voice 865.981.8000 | Fax 865.981.8010 | maryvillecollege.edu

WORKS CITED

Ali A and Williams C. 2009. Carbohydrate ingestion and soccer skill performance during prolonged intermittent exercise. Journal of Sports Sciences. 27(14): 1499-1508.

Backhouse SH, Ali A, Biddle HJS, and Williams J. 2007. Carbohydrate ingestion during prolonged high-intensity intermittent exercise: impact on affect and perceived exertion. Scand J Med Sci Sports. 17: 605-610.

Baker LB, Rollo I, Stein KW, and Jeukendrup AE. 2015. Acute effects of carbohydrate supplementation on intermittent sports performance. Nutrients. 7(7): 5733-5763.

Bangsbo J, Iaia FM, and Krustrup P. 2007. Metabolic response and fatigue in soccer. International Journal of Sports Physiology and Performance. 2:111-127.

Burke ML, Claassen A, Hawley JA, and Noakes DT. 1999. Carbohydrate intake during prolonged cycling minimizes effects of glycemic index of pre-exercise meal. Journal of Applied Physiology. 85(6): 2220-2226.

Burke ML, Hawley JA, Wong SHS, and Jeukendrup AE. 2011. Carbohydrates for training and competition. Journal of Sports Sciences. 29(1): S17-S27.

Carter J, Jeukendrup AE, Mundel T, and Jones DA. 2003. Carbohydrate supplementation improves moderate and high-intensity exercise in the heat. Eur J. Physiol. 446: 211-219.

Chryssanthopoulos C and Williams C. 1997. Pre-exercise carbohydrate meal and endurance running capacity when carbohydrates are ingested during exercise. Int. J. Sports Med. 18: 543-548.

Coyle FE, Coggan RA, Hemmert KM, and Ivy LJ. 1985. Muscle glycogen utilization during prolonged strenuous exercise when fed carbohydrate. J Appl Physiol. 61(1): 165-172.

Currell K, Conway S, and Jeukendrup EA. 2009. Carbohydrate ingestion improves performance of a new reliable test of soccer performance. International Journal of Sport Nutrition and Exercise. 19: 34-46.

Goedecke HJ, White JN, Mahomed H, Durandt J, and Lambert IM. 2013. The effect of carbohydrate ingestion on performance during a simulated soccer match. Nutrients. 5: 5193-5204.

Jacobson TL, Febbraio MA, Arkinstall MJ, and Hawley JA. 2001. Effect of caffeine co-ingested with carbohydrate or fat metabolism and performance in endurance-trained men. Exp. Physiol. 86(1): 137-144.

Jeukendrup AE. 2011. Nutrition for endurance sports: marathon, triathlon, and road cycling. Journal of Sports Science. 29(1): S91-S99.

Jeukendrup AE and Jentjens R. 2000. Oxidation of carbohydrate feedings during prolonged exercise. Sports Med. 29(6): 407-424.

Kanter M. 2018. High-quality carbohydrates and physical performance. Nutrition Today. 53(1): 35-39.

Karelis DA, Smith WJ, Passe HD, and Peronnet F. 2010. Carbohydrate administration and exercise performance. Sports Med. 40(9): 747-763.

Maughan RJ. 1997. Energy and macronutrient intakes of professional football (soccer) players. Br F Sports Med. 31:45-47.

Mohr M, Krustrup P and Bangsbo J. 2011. Match performance of high-standard soccer players with special reference to development of fatigue. Journal of Sports Science. 21(7): 519-528.

Mujika I and Burke LM. 2010. Nutrition in team sports. Annals of Nutrition and Metabolism. 57(2): 26-35.

Neufer DP, Costill ID, Flynn GM, Kirwan PJ, Mitchell BJ, and Houmard. 1987. Improvements in exercise performance: effects of carbohydrate feedings and diet. J Appl Physiol. 62(3): 983-988.

Rauch HGL, Rodger I, Wilson RG, Belonje DJ, Dennis CS, Noakes DT, and Hawley AJ. 1995. The effects of carbohydrate loading on muscle glycogen content and cycling performance. International Journal of Sports Nutrition. 5: 25-36.

Saunders MJ. 2007. Co-ingestion of carbohydrate-protein during endurance exercise: influence on performance and recovery. Int. Journal of Sports Nutrition and Exercise Metabolism. 17: S87-S103.

Zeederberg C, Leach L, Lambert VE, Noakes DT, Dennis CS, and Hawley AJ. 1996. The effect of carbohydrate ingestion on the motor skill proficiency of soccer players. International Journal of Sport Nutrition and Exercise. 6(4): 348-355.