1-1-2016

Efficacy of Carbohydrate Ingestion during Training on Crossfit Performance

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By

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A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Kinesiology
in the Department of Kinesiology

Mississippi State, Mississippi

August 2016

Efficacy of carbohydrate ingestion during training on CrossFit performance

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Pages in Study 34

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This study was designed to investigate carbohydrate supplementation during high intensity exercise and its effect on performance. Eight subjects participated in four trials; two familiarization trials, a carbohydrate trial, and a placebo trial. Fight Gone Bad Five is a CrossFit "Workout of the Day" (WOD) involving 5 rounds of 5 exercises each completed for one minute followed by a one minute rest. The exercises of the Fight Gone Bad WOD include medicine ball wall throws, sumo deadlift high pull, box jumps, push press, and rowing. Performance was measured by the summation of repetitions for the first four exercises and the caloric expenditure from the rowing session. Performance scores for carbohydrate and placebo trials were analyzed using a paired sample t-test, which found no significant difference between the carbohydrate and placebo trials.

DEDICATION

I dedicate this thesis to my dad, Chief Jeffrey "Scott" Rountree, for his unconditional love, support, and encouragement. Above all, I dedicate this to God. Colossians 3:23.

ACKNOWLEDGEMENTS

First and foremost, I want to thank my committee chair, Dr. JohnEric Smith. You trusted me enough to take me as a student and let me do this project without hesitation. Your bend but not break mentoring style has given me the confidence and independence I need to succeed past graduate school. You have made me a better student, researcher, and person and for that I am forever grateful.

I would also like to thank my other two committee members, Dr. Megan Holmes and Dr. Adam Knight. Both of you were vital throughout my graduate school experience with helping me with all aspects of this program and life. Your doors were always open for anything I needed. Most of all, you kept me humble, especially when my alma mater beat yours. Roll Tide.

I would like to thank my boss, professor, and friend, Dr. Matthew McAllister. You have taught me leadership, determination, and confidence. Your constant encouragement and challenges have made me strive to be a better student and researcher. You truly lead by example. Philippians 2:3.

Last but not least, I would like to thank the fellow graduate students. You have unknowingly helped me so much throughout the past two years. You were supportive to me through the frustrations and through the celebrations. I would not have wanted to go through this journey with anyone else.

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CHAPTER I

INTRODUCTION

CrossFit is a workout trend that was founded in 2000 by Greg Glassman (Sternkopf, 2012) and is described as an exercise-training program that aims to improve fitness through the utilization of a constant variety of functional movements (Glassman, 2007). CrossFit mimics real life, functional movements, which has led to it becoming a popular trend in exercise programming (Sanders & Fitzsimmons, 2012).

Originally using CrossFit to train the Santa Cruz police department, Glassman's workout regimen is suited for training service men and women (O'Connor, 2014). The functional movements and diverse workouts are used to prepare this particular group of people for any situation. Over 7,000 U.S. military members used CrossFit training in 2006 with major CrossFit installations at bases such as the Pentagon, Fort Knox, and the United States Military Academy (Paine, Upgraft, & Wylie, 2010). CrossFit workouts have been shown to benefit performance and fitness levels of the Canadian army (Glassman, 2006), American army (Paine et al., 2010), Police officers (Barlow & Cascella, 2010), Marines (Kostielney, 2009), SWAT team members (Hayes, 2009), and Firefighters (Gilson, 2007). Likewise, Kansas State University is currently preparing a $2.5 million, four-year study to determine whether CrossFit should or should not be the primary physical training program for the Army (Anderson, 2014).

The fitness trend of CrossFit training has spread to places such as Africa, Asia, Europe, and Australia (Etchecolatz & Mitchell, 2013). In 2012, over 5,000 CrossFit affiliate gyms, also known as CrossFit boxes were established worldwide (Toledano, 2012). By July 2014, the number of CrossFit boxes had more than doubled (Fainaru-Wada, 2014). Also, in 2014, 209,545 people participated in the first round qualifier, known as the CrossFit Open, for the CrossFit Games (Dawson, 2015). According to the Reebok CrossFit Games, the first CrossFit Open was installed in 2011 with 27,000 CrossFit athletes participating. The 2015 CrossFit Open had over 272,000 participants from all over the world ("The Open," 2015). Due to the rise in popularity, CrossFit has signed a television contract with ESPN to show the CrossFit games in the television market (McDonald, 2014).

CrossFit uses three standards to determine fitness (Glassman, 2002). The first standard is becoming proficient in the ten general physical fitness domains: cardiorespiratory endurance, stamina, strength, flexibility, power, speed, coordination, agility, balance, and accuracy. The second standard is being able to perform any athletic task, even if it is unfamiliar. The third standard is the ability of athletes to perform well across the three metabolic pathways (phosphagen, glycolytic, and oxidative) that provide energy for all human activity (Paine et al., 2010). CrossFit workouts focus on three distinct modalities: metabolic conditioning, gymnastics, and weightlifting. Metabolic conditioning refers to exercises intended to increase efficiency of energy delivery. Exercise movements included are jump roping, running, rowing, and biking. The primary purpose of the gymnastic modality is to improve body control through developing neurological adaptations, in addition to, improving functional upper body muscular

capacity and trunk strength through a variety of body-weight exercises, such as, squats, push-ups, and pull-ups (Glassman, 2003). The weightlifting portion utilizes Olympic and power lifts, such as dead lifts and power cleans, to primarily increase strength, power, and hip/leg capacity. Each day a CrossFit trainer provides a workout of the day (WOD), which is focused on one particular modality or combination of modalities. CrossFit does not take a routine approach with workouts, therefore WODs will have considerable variation (Glassman, 2003).

Workouts are divided into categories, including Benchmark and Hero workouts, which are amongst the most popular categories. Hero workouts, named after military members, police officers, and firefighters, are more difficult and geared towards elite CrossFit athletes. Benchmark and Hero workouts can both range in duration and intensity. A popular, short duration benchmark workout is the Fran, consisting of three rounds of thrusters and bar muscle-ups with decreasing repetitions of 21, 15, and 9. A thruster is a squat to an overhead press using a weighted barbell (Oh, 2013) and a muscle-up is transitioning from a pull-up to a dip in one fluid movement (Giblin, 2014). An example of longer duration hero workouts is the Murph. Murph is a workout for time consisting of a one-mile run, 100 pull-ups, 200 push-ups, 300 squats, followed by another one mile run (Herz, 2014).

Due to recent rapid growth in popularity, CrossFit practices have surpassed research efforts to understand the demands of the training. Current research efforts focus predominately on injuries and lifting technique, with few studies investigating nutritional supplementation. The paucity of research could, in part, be due to the current lawsuit between CrossFit and the National Strength and Conditioning Association (NSCA) and

Ohio State University. Two researchers from Ohio State University, Michael Smith and Steven Devor, investigated CrossFit's impact on aerobic fitness and body composition. The study started with 54 participants and 43 of them finished the study. The researchers found significant differences in body composition and $\dot{V}O_{2max}$; however, they claimed that 9 of the 11 participants who quit, quit due to overexertion or injury (Smith, Sommer, Starkoff, & Devor, 2013). Mitch Potterf, the owner of the CrossFit box where the data was collected, sued the researchers and NSCA for defamation and fraud due to the injury numbers, claiming the participants did not quit due to injury. CrossFit sued NSCA for false advertising and unfair competition for publishing the article (Greeley, 2014). Further, Dr. John Porcari, who led a 2013 study sponsored by the American Council on Exercise, said "I think people shy away from studying it because [CrossFit leaders] are so aggressive in their attacks on anybody who says anything bad about CrossFit" (Anderson, 2014).

The limited CrossFit research available mainly focuses on improving body composition. Some research regarding nutritional supplementation and CrossFit performance exists, but primarily focuses on protein (Urbina et al., 2013; Outlaw et al., 2014). Since carbohydrate is a primary fuel source during high intensity activities (Romijn et al., 1993), such as those that comprise CrossFit workouts, more research is needed to understand the influence of exogenous carbohydrate supplementation on CrossFit performance. The purpose of this study is to improve our understanding of the impact of carbohydrate supplementation during CrossFit performance.

CHAPTER II

LITERATURE REVIEW

Metabolic energy systems make ATP to be used as energy for the body during different levels of exercise intensity. During the highest intensity of the physical exertion, the ATP-PCr system serves as the predominant fuel source. Creatine phosphate provides a reserve of phosphate energy to regenerate ATP from ADP, as ATP is converted to ADP as the result of physiological function. However, the maximal capacity of the ATP-PCr energy system is 11.1 kcals (Brooks, Fahey, & Baldwin, 2005). Glycolysis is the breakdown of glucose or glycogen into pyruvate, which can be converted into acetyl coenzyme A and used in the Krebs cycle. The majority of the energy supplied for ATP production comes from the Krebs cycle. Krebs cycle, also known as the citric acid cycle, oxidizes pyruvate, from glycolysis, and lipids to CO_2 and H_2O in the production of energy (Hames & Hooper, 2011). When the body is recovering between high intensity intervals, glycolysis and Krebs cycle are predominately used as the ATP producing metabolic pathways. Carbohydrate (primarily glucose) is the main fuel source for high intensity workouts and is utilized during glycolysis and the Krebs cycle (Brooks, 1998).

The military and first responder origins and continued popularity of CrossFit make this group ideal for investigations regarding potential nutritional needs during workouts. Carbohydrate supplementation has shown positive benefits during training of service men and women. The Navy Seal Nutrition Guide promotes carbohydrate

supplementation due the high amount of activity military jobs demand, but give no guidelines regarding performance enhancement (Deuster, Pelletier, & Singh, 1998). According to National Academies (2009), carbohydrate supplementation enhances performance and decreases fatigue in army training. Leiberman (2003) has shown carbohydrate supplementation to enhance cognitive performance in soldiers engaged in sustained, intense physical activities that expend high levels of energy. In addition, carbohydrate supplementation was shown to improve total work accomplished by wildlife firefighters during strenuous wildfire suppression (Ruby, Gaskill, Harger, Hell, & Sharkey, 2004). Benefits of carbohydrate supplementation in service training of similar workouts suggests that those benefits may extend to CrossFit performance.

Since CrossFit is a high intensity interval based exercise, it can also be compared to sports such as football, which require athletes to complete repeat short duration high intensity bouts of activity. A small amount of research has been examined on the effects of carbohydrate supplementation and performance during football. Smith, Lee, Dobson, Roberts, & Jeukendrup (2013) used non-contact football drills with rest periods to examine the efficacy of carbohydrate supplementation in this type of activity. Drills consisted of prowler pushes, four-cone drill, three-cone drill, ladder drill, bear-crawl, and 20-yd shuttle. Carbohydrate supplementation attenuated performance declines compared to when carbohydrate was not ingested. These results are applicable in the CrossFit realm, as many of the same types of movements and work to rest ratios are utilized.

In a similar study, Crawford found a positive influence on performance in football players (Crawford, Miller, Womack, Green, & Crouse, 2005). Football players pushed sleds to simulate game type activity and were assessed for performance using jump and

reach tests. When carbohydrate was supplemented at halftime, improvements were seen for average power output. Again, these activities are similar to those of a typical CrossFit workout.

Since research on carbohydrate supplementation in team sports, such as football is limited, interval running and cycling may also be a comparison to CrossFit. A study in 2010 found, carbohydrate supplementation during intermittent running did not result in a significant decrease during time trial performance, however a 1,000 meter run was conducted post time trials and the carbohydrate group had significantly lower times when compared to placebo group (de Sousa et al., 2010). In addition, Davis, Jackson, Broadwell, Queary, and Lambert (1997) conducted a study on high intensity intermittent cycling with carbohydrate ingestion before and during exercise. Results from this study indicated that carbohydrate supplementation delayed time to fatigue. The authors of this study also suggested other sports could also benefit from carbohydrate supplementation.

CrossFit is fairly new in the realm of exercise and research efforts have only just begun to examine the influence of nutritional supplementation. Research on supplementation during CrossFit workouts has predominately focused on pre- and post-workout supplements with particular emphasis on protein supplementation. An investigation conducted by Outlaw et al. (2014) investigated the effects of protein and protein plus carbohydrate shake taken for pre-workout supplementation and post-workout protein shakes over a six-week training duration. The CrossFit training included two different WODs. The first WOD consisted of 500 m row, 40 wall balls, 30 push-ups, 20 box jumps, and ten thrusters for time and the second WOD consisted of 800 m row followed by as many rounds as possible (AMRAP) in twenty minutes of 5 burpees, 10

kettlebell swings, and 15 air squats. Data showed there was a significant improvement in WOD performance times after six weeks of taking protein plus carbohydrate compared to the placebo group. This research suggests nutritional supplementation such as protein and carbohydrate can be beneficial for chronic CrossFit training however there is a gap in the literature in nutritional supplementation in acute CrossFit training.

Determining the intensity of CrossFit is difficult due to the lack of research and belief that $\dot{V}O_{2max}$ is not the gold standard for measuring intensity during CrossFit (Leyland, 2006). Babiash, Porcari, Steffen, Doberstein, and Foster (2003) found while doing the Donkey Kong (a common CrossFit WOD consisting of 21-15-9 repetitions of burpees, kettlebell swings, and box jumps) and Fran WODs, percent of heart rate max ($\%HR_{max}$) was in the lower 90's and $\%\dot{V}O_{2max}$ ranged in the mid 80's. The intensity of CrossFit can often exceed 100% of the $\dot{V}O_{2max}$ (supramaximal), especially during shorter intense workouts. With workloads at or exceeding maximal aerobic capacity, muscle glycogen levels have been shown to rapidly decline which may elicit more rapid muscle fatigue (Gollnick, Piehl, & Saltin, 1974). Glycogen is a readily mobilized, endogenous fuel substrate and can be broken down to yield glucose molecules when needed (Berg, Tymoczko, & Styer, 2002). Exogenous carbohydrate supplementation could potentially delay glycogen depletion (Tsintzas, Williams, Boobis, & Greenhaff, 1995). However, further research is needed to investigate the exercise intensity of CrossFit participants and what supplementation is ideal for their performance.

Previous investigations have shown carbohydrate supplementation during high intensity, intermittent activity can be beneficial for performance. However, a gap in the literature exists regarding carbohydrate supplementation in high intensity strength and

conditioning type of training. The body utilizes exogenous carbohydrate first before partially sparing glycogen stores during strenuous exercise (Coyle, Coggan, & Hemmert, 1986). Exogenous carbohydrate could play an important role during CrossFit workouts because in one exercise bout at 120% of VO_{2max}, glycogen stores can be depleted in as little as 20 minutes (Gollnick et al., 1974). The high intensity of CrossFit makes an ideal model for examining the influence of exogenous carbohydrate on performance. Periodic carbohydrate supplementation during workouts and/or competition may be key to maximizing performance.

CHAPTER III

METHODS

Subjects

Eight healthy, college aged (22 ±1.8 years) males participated in the study. The purpose of this study was to examine whether carbohydrate supplementation affects performance during CrossFit. Thus, only well-trained CrossFit athletes were selected for the study. To be considered well-trained, the participants had at least six months of resistance training experience as well as at least three months of CrossFit specific training. Data was collected at the AMPED training zone on Mississippi State University's campus with participants from the Starkville, MS area. The experimental protocol was approved by the Mississippi State University Institutional Review Board.

Procedure

The Fight Gone Bad Five (FGBF) WOD benchmark workout was used as the exercise intervention. FGBF is five rounds of wall-ball, 34 kg sumo deadlift high-pull, box jump, 34 kg push-press, and rowing. For wall-ball, a 9 kg medicine ball (Dynamax, Inc., Austin, TX) was used. The participant was instructed to hit a target ten feet in the air and catch the ball for the repetition to count. For box jump, the box was a 50.8 cm tall wood jerk block (Rogue Fitness, Columbus, OH). Each station was a minute long. The repetitions for wall-ball, sumo deadlift high-pull, box jump, and push press were assessed and counted by a Level 1 CrossFit trainer. The same CrossFit trainer was used for the

entirety of the study for consistency. In order to quantify performance, one point was given for each repetition, except for rowing. Rower (Model D, Concept2 Inc., Morrisville, VT) performance was measured as caloric expenditure (kcal) with each kcal counted as a point on a rowing ergometer. After completing each of the five stations, participants had one minute of rest before the next round started. The FGBF WOD lasted 30 minutes exactly.

Prior to performing FGBF WOD, a warm-up was performed. The warm-up consisted of four different exercises: rowing, lunges with arm circles, 4.5 kg wall-ball (Dynamax, Inc., Austin, TX), and bear crawls. The rowing portion was two minutes with resistance set to five, which was the same resistance for the rowing portions during the exercise interventions. Participants were encouraged to keep their cadence between 20-25 strokes per minute for consistency. The remaining three exercises were 30-second durations. Participants were given a minute of rest after completing the warm-up before the exercise trial started. Following completion of exercise trial, the participant was given a few minutes to stretch followed by a ten-minute cool down on the rower.

Each participant completed four trials. Each trial was separated by at least a week. Each trial consisted of the warm-up, FGBF, and cool down. The first two trials served as familiarization trials to allow any learning effects of FGBF to stabilize (Scott & Docherty, 2004). The first trial required no restriction on fluid type or intake volume during the session. During the second trial each participant was restricted to 41.6 ml of water provided immediately prior to the warm-up, prior to the initiation of the FGBF exercises, and during the one minute rest breaks within FGBF, exactly like the schedule and intake volumes in the third and fourth trial. The third and fourth trial were conducted

using a double blind, cross-over design with either a placebo or the carbohydrate supplement before the warm-up, after the warm-up, and at each of the four rest periods during the exercise session. Participants did the exercise sessions alone and without music to reduce influence from external factors.

Each participant was instructed to consume the same foods and beverages three days prior to each trial. Likewise, participants were instructed to fast 10 – 12 hours before each session, consuming only water to maintain hydration status during that time. Participants were asked to refrain from any resistance training 48 hours prior of sessions. Since hypohydration has shown decrements in performance in previous research (Shirreffs, 2005), each participant drank a 1 L of water before bed the evening prior of the research session and another 1 L the morning of the research session. Hydration was assessed using refractometer (PAL – 10S Pocket Refractometer, Atago, Tokyo, Japan) assessments of urine specific gravity. The cut off point for hydration was set to 1.025 AU. If the participant was not sufficiently hydrated, his trial was rescheduled. For each trial, pre- and post nude body weight were recorded. Additionally, all participants abstained from consuming any additional supplementation, including caffeine, throughout the entirety of the study.

Supplementation

Carbohydrate and placebo supplementation were provided by Sqwincher (The Sqwincher Corporation, Columbus, MS). The carbohydrate supplement was a 6% carbohydrate solution with the main ingredients listed as sucrose and dextrose, both rapidly oxidized carbohydrates (Jeukendrup & Jentjens, 2000). Participants received 16 grams of carbohydrates over thirty minutes during the supplementation trial. The placebo

was a non-caloric mixture known as Sqwincher Zero containing sucralose/aspartame to mimic the sweetness of the carbohydrate solution. Beverages were provided in opaque bottles and carbohydrate supplement and placebo had the same amount of sodium and potassium and were the same flavor (fruit punch).

Statistical Analysis

In order to determine an overall influence of carbohydrate supplementation on CrossFit performance, the decision was made, a priori, to assess CrossFit performance as the total amount of work completed in the comparative interventions. The primary analysis was based on the amount of work performed. Summation of the repetitions was compared between treatments using a student paired t-test in the Statistical Package for the Social Science (SPSS, Version 23; SPSS Inc., Chicago, IL) program with alpha level set at $P < 0.05$. The secondary analysis was a 5 x 2 repeated measures ANOVA analyzing the scores from the five individual rounds with the two intervention trials to determine if there was a main effect between round scores. As appropriate, a Bonferroni post hoc was performed to identify the differences between rounds, when main effects were identified.

CHAPTER IV

RESULTS

Nine participants were recruited for this study, eight completed all of the exercise trials. One withdrew from the study due to external scheduling conflicts. Participant characteristics are listed in Table 1.

Table 1

Physical Characteristics of the Participants

CrossFit athletes (n=8)	
	Mean ± SD
Age (years)	22 ± 1.8
Height (cm)	177.6 ± 6.2
Mass (kg)	81.3 ± 7.2

The FGBF scores were determined using CrossFit standards, summating repetitions from all four exercises and kcal expenditure from rowing. Mean FGBF scores from the carbohydrate and placebo trials were compared using student paired t-test with an alpha level of $P < 0.05$. As seen in Figure 1, no significant differences were observed between carbohydrate and placebo trials (Fig. 1, $P = 0.38$).

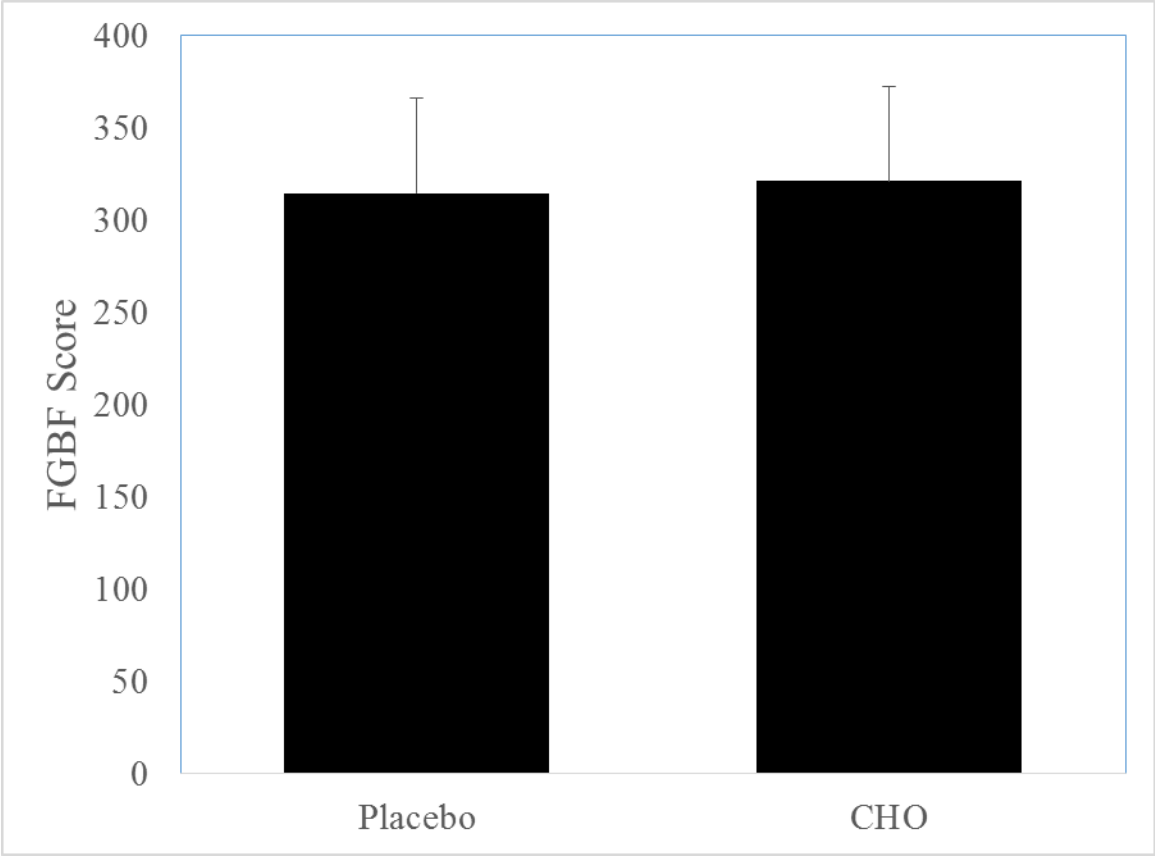

Figure 1. Fight Gone Bad scores comparing placebo to carbohydrate (CHO)

When using a 5 x 2 repeated measures ANOVA to compare rounds to treatments, a significant main effect was observed. Bonferroni post hoc indicate there was a significant difference in performance between round one compared to rounds two, three, and four ($P \leq 0.002$). However, there was no significant difference between rounds one and five ($P = 0.105$).

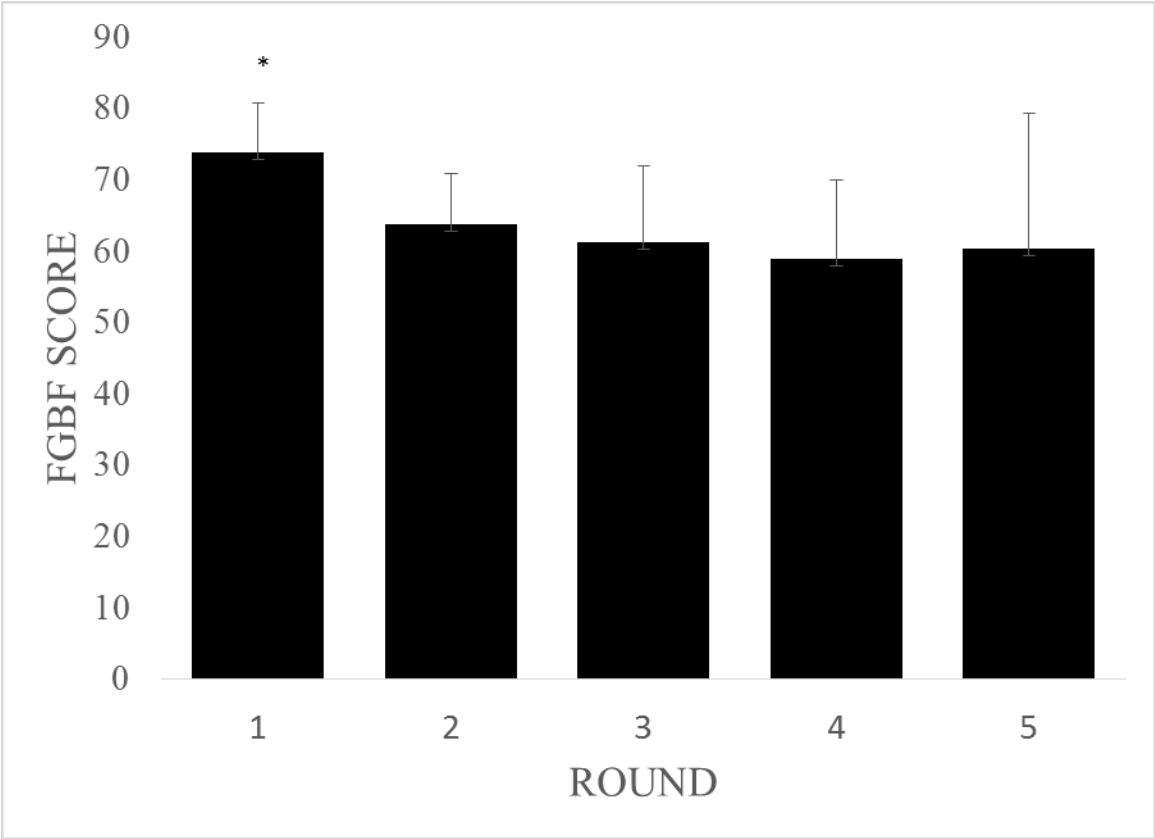

Figure 2. Fight Gone Bad round comparison

FGBF scores by round compared using a 5 x 2 ANOVA ($P < 0.05$). * Significantly different from round 2,3,4. Error bars represent standard deviation.

CHAPTER V

DISCUSSION

Carbohydrate supplementation has been shown to be an ergogenic aid for various types of exercise (Cermak & van Loon, 2013). Similarly, carbohydrate supplementation has consistently been demonstrated to increase performance in endurance activities such as cycling and running (Karelis, Smith, Passe, & Peronnet, 2010) and delay fatigue and increase performance in resistance training (Wax, Brown, Webb, & Kavazis, 2012). Recent research also suggests that high intensity interval training performance can benefit from carbohydrate supplementation during exercise (Hawley, Gibala, & Bermon, 2007), however carbohydrate ingestion benefits were not evident in CrossFit training in the current investigation.

Previous CrossFit research has reported benefits from carbohydrate supplementation during an exercise bout, however there were variations amongst the supplements in terms of protein and caffeine. Outlaw et al. (2014) found performance improvements during WODs over the course of six weeks of training, but with other known ergogenic aids, such as protein, when compared to a placebo. In the present investigation, the two experimental trials were separated by approximately one week. The current research investigation may have elicited similar findings if the study duration was longer. Likewise, the deviation of the findings of the present study from previous

research may also be due to the absence of additional ergogenic aids which may have been an influence in previously mentioned study.

Another possible reason carbohydrate supplementation did not affect performance in the present study may be due to the duration of the individual CrossFit workouts in the current investigation. Prior research, like the previously mentioned study by Outlaw (2014) has shown benefits in carbohydrate supplementation in chronic CrossFit training, however there is a gap in the research investigating carbohydrate supplementation and acute short duration CrossFit training. Previous research suggests carbohydrate supplementation improved high intensity interval training performance over 40 minutes (Anantaraman, Carmines, Gaesser, & Weltman, 1995). According to the CrossFit Leaderboard, two out of the thirteen events (Pier Paddle and Murph) in the 2015 CrossFit Games lasted at least 38 minutes. Even recreational CrossFit training sessions last 45 minutes to an hour, which includes a dynamic warm up, skill/strength work, WOD, a cool down, and stretching (Kamb, 2012). Since carbohydrate supplementation did not benefit the thirty minute FGBF workout, carbohydrate supplementation should be further investigated in longer duration CrossFit workouts and training sessions.

CrossFit has three components of fitness incorporated into training: interval training, gymnastics, and weightlifting (Glassman, 2002). FGBF does not contain any gymnastic movements, such as muscle-ups, headstands, or pull-ups, but does contain the interval training and weightlifting CrossFit components (Glassman, 2002). Although research in weightlifting does not suggest benefits from carbohydrate supplementation (Baty et al., 2007), previous research in interval training has suggested carbohydrate supplementation can improve performance (Anantaraman et al., 1995). However, the

study by Anantaraman et al. (1995) had several differences compared to the methodology used in the present study, such as concentration of the carbohydrate supplementation (10%), duration of the trial, and type of exercise used (cycling).

The current investigation utilized a 6% carbohydrate beverage within resistance training. Previous resistance training research did not see a benefit with 6% carbohydrate supplementation. Clarke, Kornilios, and Richardson (2015) investigated carbohydrate and caffeine supplementation in resistance training. Even though the study was only on bench press performance, there was no significant difference when carbohydrate was supplemented. The similar concentration studied during resistance training performance compared to the current investigation of 6% carbohydrate solution suggests the null results in the present investigation were not surprising. Since previous research suggests benefits from higher concentrations of carbohydrate (Anataraman et al., 1995), a higher concentration of carbohydrate should be considered for future research in CrossFit.

Since the FGBF workout is predominately a muscular endurance training exercise, a more aerobic CrossFit workout may potentially benefit from carbohydrate supplementation. Past research suggests carbohydrate ingestion during high intensity interval training improved performance and delayed fatigue (Davis et al., 1997). However, the consistency of this benefit varies by type of exercise. Multiple studies examining high intensity interval aerobic training have demonstrated benefits of carbohydrate supplementation (Anantaraman et al., 1995; Hawley et al., 2007). Contrastingly, high intensity muscular endurance training does not benefit from carbohydrate supplementation. Kulik et al. (2008) used a high intensity interval squat program to failure with no significant improvement from carbohydrate supplementation.

Haff et al. (2000) who used a 30-minute muscular endurance protocol, similar to the duration of FGBF, and did not report a significant difference due to carbohydrate supplementation. Future research should investigate carbohydrate supplementation in the longer duration CrossFit WODS, such as the Murph and Pendleton 1 (swim 700m and bike 8km).

The primary objective of the study was to determine the efficacy of carbohydrate ingestion during a high intensity training session. Performance during a high intensity exercise session while consuming a carbohydrate-electrolyte beverage was compared to the same performance measures when a non-caloric placebo was ingested. The findings of this study suggest the ingestion of carbohydrate intermittently during CrossFit workouts has no effect on performance. The fact that carbohydrate did not hinder performance has practical implications for casual and professional CrossFit athletes. The allowance of a carbohydrate beverage during training sessions may aid in the insurance of adequate hydration and caloric intake which has shown to affect performance.

Conclusion

The growth in popularity of CrossFit has not only been shown in recreational CrossFit but also CrossFit competition (Dawson, 2015). However, research in CrossFit is scarce, especially in performance. With less than a 1% chance for people to qualify for the CrossFit Games (Tromello, 2016), research in ways to benefit CrossFit performance is essential. Although carbohydrate supplementation did not show significant improvements in CrossFit performance in the present study, further research is needed in this area and may benefit from focusing on training duration and dosage levels. This

study was an important initial step in understanding the influence of a common ergogenic aid during relatively novel exercise training.

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APPENDIX A

FIGHT GONE BAD FIVE EXERCISES

Figure A1. Wall-ball starting and ending phases

Figure A2. Sumo deadlift high-pull starting and ending phases

Figure A3. Box jump starting and ending phases

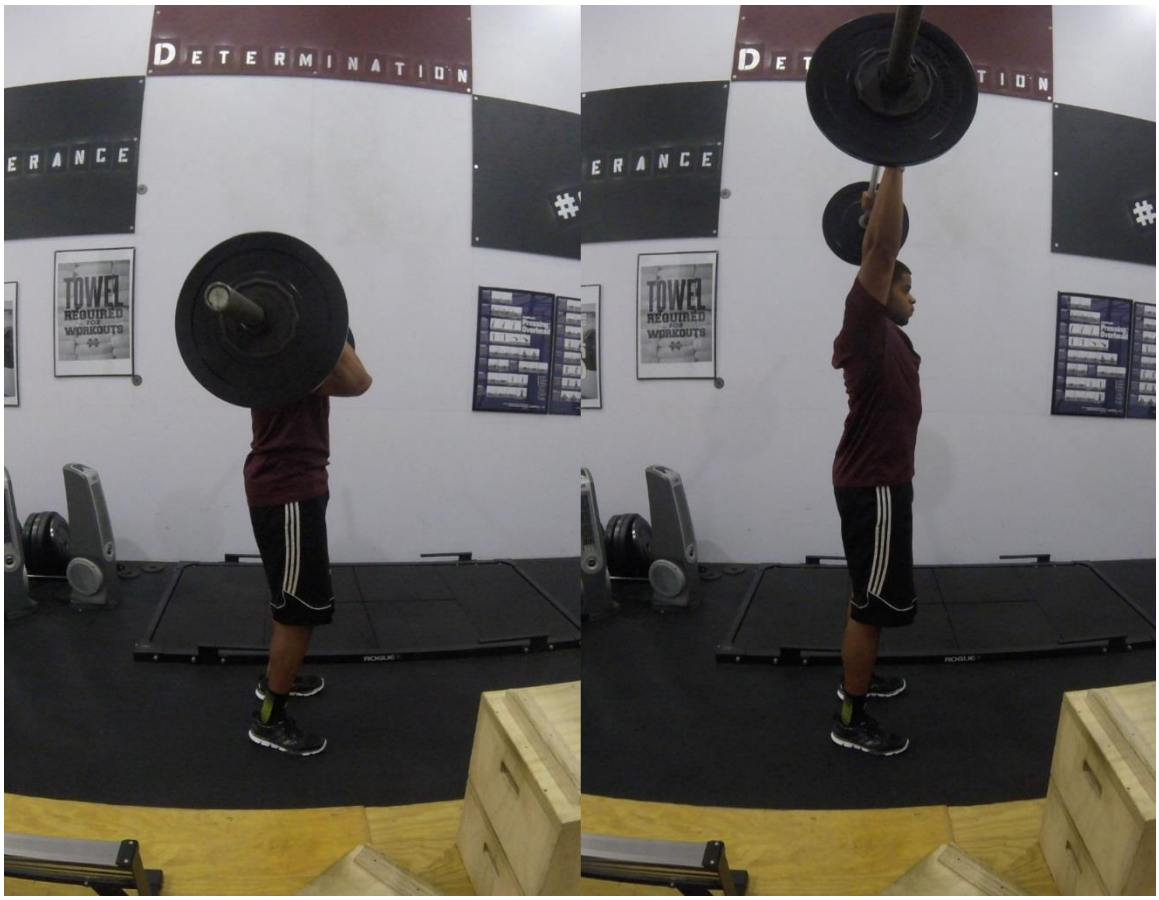

Figure A4. Push press starting and ending phases

Figure A5. Rowing starting and ending phases