Effects of Sports Drinks on the Performance of Young Soccer Players

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(ABSTRACT)

This study examined the effects of a sports drink on the performance of young soccer players. Ten competitive young male soccer players, ages 10 and 11, performed two experimental trials while consuming 32 ounces of either a sports drink (G)- Gatorade or a placebo (P)- Crystal Light in a double-blind, crossover design. Both trials consisted of a 15-minute warm-up period, a pre and post exercise test protocol and a 40-minute indoor scrimmage with a five-minute half time. The assigned fluid was consumed just prior to the warm-up, pre-test protocol, scrimmage and post-test protocol as well as during the half time of the scrimmage. The exercise tests included six activities such as shooting velocity, dribbling, passing, jumping, backward running, and sprinting in order to measure skill, agility, power, and speed. The results showed that due to the interaction of the 40-minute scrimmage and the consumption of Gatorade, the post-test shot velocity measurement was significantly ($p<0.01$) lower for P while G remained similar to the pre-test measurement. Also, there was a significant ($p<0.05$) decrease in the number of jumps completed for both P and G during the post-test jumping exercise when compared to the pre-test measurement. However, there were no significant difference of treatment, time and/or their interaction for the dribbling, passing, backward running, and sprinting.

Many possible reasons may account for this lack of effect. 1) Muscle glycogen may not have been substantially depleted, possibly because the prescribed exercise during the trial was not intense or long enough. 2) Prior to the experimental trials, muscle glycogen stores were sufficient where no additional CHO was necessary (due to the subject's diet on the day of the trial or the short fast prior to the experimental trials). 3) Alternative mechanism, such as increased lactate production or dehydration and not muscle glycogen depletion, may be the cause of impaired skills. 4) A child's increased fat utilization allows for less of a need for manipulation of glycogen stores.

DEDICATION

I would like to dedicate this to my grandmother and great aunt who have recently passed away: two amazing and inspirational sisters whose wisdom, independence, sense of humor, and unselfishness helped me in so many ways. I greatly admire, cherish and miss both of you. I love you!

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INTRODUCTION

Introduction:

Soccer is the world's most popular sport with competitors of all ages and abilities. Many of these participants, at even a young age, train and compete at intense levels, striving to improve their performance and become a top, unbeatable player. At high levels of play, the demands of soccer require a player to be exceptionally fit both aerobically and anaerobically. Studies show that in a 90-minute match, older, elite males run between 8 to 13 km and expend about 800-1500 calories. The type of activity during a game includes high, moderate, and low intensity running, accelerating, jumping, tackling, and many other movements that require high amounts of energy (Bangsbo, 1991; Bangsbo, 1994; Hawley et al., 1994). Since soccer includes short, bouts of high intensity exercise for a prolonged period of time, many researchers have investigated the use of carbohydrate (CHO) on the performance of elite players. For example, Saltin (1973) found that players with low glycogen stores at the start of a game covered 25% less distance and ran at a much slower rate. And Balsom (1999) found that those players, who began the match with proper glycogen levels and continued to supply the body with CHO during the game, increased their running distance at speed by 33% in the second half.

The demands of soccer on young players are somewhat similar to that of an elite athlete. Even though an under 12 game is 60 minutes (rather than 90), a competitive young athlete exerts a great amount of energy and experiences high levels of intensities. It is important to consider the fact that children have a much higher energy cost per kg of body mass when walking or running. Unfortunately, research on the caloric cost during a youth game is lacking. Klimt's (1992) findings do show that the average heart rate for an 11-12 year old boy during a soccer game is 160-180 beats per minute. This is comparable to the elite athlete's heart rate (155-170 beats/minute). Recovery time for children is faster during short-term intense exercise and blood lactate levels are 3-4mM, which is lower than their adult counterparts. Because there does not seem to be a major accumulation of lactate, more short sprints can be accomplished, which may allow children to compete at higher intensities (Klimt, 1992; Bar-Or and Unnithan, 1994; Hebestreitit, 1993). Even with the knowledge the CHO ingestion benefits elite athletes and the game imposes similar demands on young athletes, it is unclear if consuming CHO to increase glycogen levels before and during a game will affect the performance of a young soccer player.

Many athletes, young soccer players included, choose to consume sports drinks whether it is for the added CHO or the taste preference. Because sports drinks contain CHO and CHO supplementation has been found to delay fatigue in elite athletes, manufacturers argue that sports drinks enhance performance during intermittent, high intensity and/or prolonged exercise. But, do sports drinks really contain enough CHO concentrations to benefit an athlete? Researchers have found improvements when comparing sports drinks and water while running or cycling, but unfortunately, the evidence is somewhat limited and controversial for other activities. More research on the effects of sport drinks during team sports and their effects on children in any type of activity is necessary, especially since a large number of young athletes, who mimic their favorite sports idols in commercials, consume these products with the belief that they have ergogenic effects.

In conclusion, evidence suggests that, in elite males, CHO supplementation improves running performance and fluid intake prevents skill deterioration, but it has yet to be determined whether or not a young soccer player can experience similar benefits. Since sports drinks are readily consumed and easily available to children in sports, it is a popular question whether or not they will provide performance benefits beyond the effects of water?

Specific Aims:

The purpose of this non-invasive study is to determine if sports drinks, such as Gatorade, will delay the onset of fatigue and improve the precise motor skills, speed, agility, and power of young soccer players in a competitive training environment. In order to test these different parameters, six exercise tests were performed before and after a 40-minute scrimmage on two separate occasions: one while consuming Gatorade and one while consuming a placebo. The measure of shot velocity was used to determine effect on power. The dribbling and passing exercises were used to determine effect on motor skills. The jumping and backward running exercises were used to determine effects on agility. And finally, the 40-yard sprint was used to determine the effects on speed.

Research Hypotheses:

The following null hypotheses were tested during this experiment:

H_o: Sports drink consumption, a 40-minute scrimmage, or their interaction will not affect the velocity at which a young soccer player can shoot a soccer ball.

H_o: Sports drink consumption, a 40-minute scrimmage, or their interaction will not affect the dribbling performance of a young soccer player.

H_o: Sports drink consumption, a 40-minute scrimmage, or their interaction will not affect the passing performance of a young soccer player.

H_o: Sports drink consumption, a 40-minute scrimmage, or their interaction will not affect the agility, measured by side-to-side jumping, of a young soccer player.

H_o: Sports drink consumption, a 40-minute scrimmage, or their interaction will not affect the time it takes a young soccer player to complete six backward running shuttles.

H_o: Sports drink consumption, a 40-minute scrimmage, or their interaction will not affect the time it takes a young soccer player to complete a 40-yard sprint.

Limitations:

The following limitations of this research study should be acknowledged:

1. Results only apply to the sample of 10 and 11-year old boys who play competitive soccer in the Blacksburg area and who have no health problems as defined by a medical and health history questionnaire.

2. Results are limited to this specific amount (32 oz) and type (Gatorade) of fluid consumed.

3. Results are limited to the exercise tests (shooting, dribbling, passing, jumping, backward running, and sprinting) used in this study.

Basic Assumptions:

The following basic assumptions were made prior to and during this investigation:

1. All subjects followed these necessary instructions:
    a) Fasted 2 hours prior to both trials
    b) Ate similar meals and snacks on both days of the trials
    c) Performed the experiment to the best of their ability

2. Pre-muscle glycogen levels will be similar among all subjects

3. Fitness levels and ability for each subject will vary, thereby possibly affecting the results

4. The exercise test protocol incorporates many activities performed during a soccer game and is a good measure of their ability.

CHAPTER II:

LITERATURE REVIEW

Introduction:

Previous studies have estimated the energy expended and running patterns throughout a soccer game as well as the effects of CHO supplementation on running and skill performance of elite players. However, no studies, to the investigator's knowledge, have determined CHO effects on young soccer players. Furthermore, limited studies use a sports drink as the source of CHO to find effects on performance of a soccer player. Therefore, investigating the benefits of a sports drink on a young soccer player is consequential and may help the numerous consumers who question its effectiveness. The following studies and pertinent information help show the importance of this proposed research idea: the effects of a sports drink on the performance of young soccer players.

Background Information:

Demands of soccer

Throughout a soccer game, a player expends a great deal of energy. Bangsbo (1991& 1994) has researched the energy demands and activity profile of competitive soccer and has reported that an elite male soccer player covers a total distance of about 11 km each game with the first half being approximately 5% longer (also found by Reilly and Thomas, 1976). Besides the 17% of a game that a player stands still, they walk ~40%, jog ~17%, low-speed run ~17%, and backwards jog ~1% of the time. For ~8% of the total duration, a player also runs at higher intensities which includes moderate intensity (~5%), high intensity (~2%), and sprints (~1%). The amount of running and repetition of certain movements depends on the position being played. A midfielder tends to run further at low intensity and stands still less, thereby covering more distance than forwards and defenders. Yet, each player on the field runs about the same amount of high intensity running (Bangsbo, 1991). Reilly et al. (1997) found that a player rests ~3 seconds every 2 minutes, but this time increases towards the end of the game.

The activity during a match is roughly 90% aerobic with the remaining 10% anaerobic. Of this anaerobic work, a player is estimated to sprint for about 7 minutes (includes ~19 sprints with mean duration of 2 sec; a total distance of ~530m) and perform 40-62 accelerations, 9 headers, 10 jumps (Bangsbo, 1991 and Hawley et al., 1994). Movements are not limited to only those listed. Reilly and Ball (1984) estimated that an elite player completes 1000 different changes of activity once every six seconds throughout a game which also includes tackling, decelerating, changing direction, getting up from the ground, and performing any of the numerous balls skills (dribbling, passing, receiving, shooting, etc). Reilly and Thomas (1976) also reported that a player sprints once every 90 seconds and performs a high intensity effort once every 30 seconds. When considering the energy expended during a game, one must realize that these movements greatly elevate the energy required. Therefore, researchers have estimated that during a competitive game, an elite player burns anywhere from 800-1500 calories depending on their position, style of play, the level of the opponent, and importance of the game (Bangsbo 1994; Reilly and Thomas, 1976; Reilly and Bowen, 1984; Reilly, 1997; and Ekblom, 1986).

Reilly and Ball (1984) investigated the physiological cost of dribbling a soccer ball. They had competitive soccer players run on a treadmill at four different speeds for 5 minutes each: once while dribbling a soccer ball (using a three-sided rebound box) and once without (for the control condition). $VO_{2\ max}$ was assessed as well as the rate of perceived exertion (RPE) for both trails. They found that dribbling a ball did significantly increase the energy cost by 1.24 kcal/min at each of the four speeds, and the RPE also displayed a significant effect. Nevertheless, possession of the ball only accounts for 2% of the total distance a player covers. The majority of the movement is off the ball (Reilly, 1997).

Since soccer often includes "changes-in directional modes of running", Reilly and Bowen (1984) compared the exertional costs of running forward, sideways, and backwards. In this experiment, the subjects completed the three different directional modes each at three different speeds. The nine trial runs were four minutes each. The energy cost was calculated from VO_{2max} and respiration exchange ratio while the perceived exertion was also rated. They found that the energy cost of backwards and sideways running significantly increased the energy cost up to nearly 5 kcal/min at high speeds when compared to forward jogging. The RPE for the backward and sideways running again showed a significant effect.

In order to determine the aerobic energy expenditure, researchers measure oxygen uptake (VO_2) and have found values ranging from 1-4 l/min during a match. Measurement of heart rate is another method used to determine aerobic energy expenditure. From a laboratory setting, a relationship between HR and $VO_{2\ max}$ has been found. Since it is difficult to continuously measure $VO_{2\ max}$ during a game, the measurement of HR is used to estimate its value. One should note that HR is an indirect measurement of energy production and tends to overestimate the true VO_{2max} value. The average $VO_{2\ max}$ during a game has been found to be

70-80% (Bangsbo, 1994; Ekblom, 1986; and Reilly, 1976). As noted from Bangsbo (1994), Van Gool's found that the average HR for defenders was 155 beats/min and 170 beats/min for midfielders and forwards.

Blood lactate (BLa) concentrations have been used to measure anaerobic work; unfortunately they are inaccurate and often underestimated due to several reasons. The intense bouts are possibly too short to see a considerable increase in BLa. The measurement only indicates type of activity performed in the short period just prior to sampling. And, not all of the lactate will appear in the blood due to the removal by the exercising muscles during low-intensity exercise (Bangsbo, 1994 & 1991 and Saltin, 1973). Even though the amount of BLa varies between each individual and each game, a consistent pattern shows that concentrations are higher in the first half than in the second half. Some of the values have peaked at 12 mM, yet the mean tends to be ~ 9 mM in the first half and 7mM in the second half for elite players (Ekblom, 1986). Yet, Bangsbo (1991) reported a much lower mean BLa of 4.9 mM in the first half and 3.7 mM in the second. Abt et al. (1998) reported that shooting accuracy decreases when the training load increases to anaerobic metabolism, where the heart rate is ~ 180-190 beats/minute. They suggested that a decrease in technical performance is possibly due to an increase of lactic acid, which leads to the inhibition of the muscle contractile process.

Glycogen Depletion and CHO usage

Energy used during exercise is stored in the body as glycogen (from CHO) and as fat. Fat oxidation is more prevalent in exercises at low intensities while more CHO is utilized during exercise at higher intensities. The amount of fat stored in the body could allow one to work for several days, while glycogen could be depleted rapidly depending on the nature of the exercise.

During activities lasting approximately 2 hours with exercise intensities ~60-80% of $VO_{2\ max}$, normal glycogen levels tend to be sufficient (Saltin, 1973). Even though a soccer match is 90 minutes at these intensities, the short bursts of high intensity running and other high-energy movements require a great deal of CHO utilization. Throughout a game, glycogen levels are decreased and the working muscles begin to fatigue. The body must then rely more on its fat stores thus making the player slow down which in turn hinders a player's performance. In order for a player to continue working at high intensities towards the end of the game, higher than normal glycogen stores are necessary. Bangsbo et al. (1991) reported that player covers five percent more distance in the first half than the in the second half due to the depletion of glycogen stores. Beginning an activity with higher glycogen reserves will in fact increase the available stores for the latter stages of the exercise, thereby allowing high intensity running during this time (Saltin, 1973; Jacobs et al., 1982; Bangsbo, 1994; and Shephard, 1999).

CHO ingestion before and during may prolong time to exhaustion by increasing muscle glycogen concentration, sparing muscle and liver glycogen, and/or causing a delay in gluconeogenesis which would delay the onset of hypoglycemia (Jacobs et al., 1982). Saltin (1973) found that soccer players who began a game with low glycogen levels covered 25% less distance. An important factor that may affect performance was the decrease in running speed. Players with low initial stores walked 50% of the total distance and ran 15% at top speed compared to 27% walking and 27% sprinting for players with high muscle glycogen levels at the start of the game. Kirkendall et al.'s (1993) study showed that players who consumed a glucose polymer solution covered 25% greater distance with 40% at speed. Leatt and Jacobs (1989) also noted that CHO decreased muscle glycogen use by 39% during a game. Increasing ability to run more at higher intensities may be the difference in the outcome of a game. More goals tend to be scored at the end of a soccer game and/or during the bursts of high intensities (Reilly, 1996). Whether this is due to those players with higher glycogen stores or better aerobic fitness (which allows for a continued high work rate (Reilly, 1976), or just the fact that more risks are being taken is still unexplained.

Countless researchers have examined the effects of CHO and exercise. Different types and amounts of CHO have been utilized on a variety of sports, exercises and individuals. Timing of consumption has also been investigated.

Effects of CHO on prolonged exercise

It is well documented that CHO ingestion before and during events lasting longer than 2 hours can delay fatigue and increase time to exhaustion. The following studies use well-trained athletes completing either a running or cycling exercise protocol at 60-80% $VO_{2\ max.}$ Coyle et al. (1983) reported that cyclist exercising at 70% of $VO_{2\ max}$ rode to exhaustion significantly longer ($p < 0.01$) after consuming CHO (4 g/kg body wt) during their ride. In another experiment, Coggan and Coyle (1987) compared the ingestion of a placebo, the ingestion of a glucose polymer and the infusion of glucose. Both the infusion and ingestion of CHO during exercise significantly increased the time to fatigue {($p<0.01$) and ($p<0.05$) respectively}. In Davis et al.'s (1988) study, subjects cycled for 2 hours, rested for 30 minutes, and then completed 2700 pedal revolutions as fast as possible on three separate occasions. A water placebo, a moderate (6%) CHO-electrolyte, or a low (2.5%) CHO-electrolyte beverage was consumed every 20 minutes of the exercise. Significant performance differences were only found in the later stages when comparing the placebo trial to the moderate CHO trial ($p<0.02$).

Wright et al (1991) compared placebo feedings to CHO (8%) feedings pre-exercise (PC), during exercise (PC), and in combination (CC). Well-trained cyclists rode to exhaustion at 70% of $VO_{2\ max.}$ The time to exhaustion was significantly longer with the CHO feedings. Total work completed was increased for CC, PC, and CP (44%, 32%, and 18% respectively). Murray et al. (1991) examined subject's responses to different amounts of CHO levels during prolonged cycling at 65-75% of $VO_{2\ max.}$ Subjects consumed: a placebo; or 26, 52, or 78 g of CHO /hour (6, 12, or 18% CHO). Time to complete the 4.8-km was longer for the placebo trial. The 6% and 18% showed a significant decrease in time ($p<0.05$).

However, Flynn et al. (1987) investigated the effects of different types of CHO (maltodextrin and fructose, maltodextrin and high fructose, and maltodextrin and glucose) compared to water during 2 hours of cycling. They found that the amount of work completed was not significantly different, possibly due to the similar initial glycogen levels.

The last few studies use running as the exercise test protocol. Millard-Stafford et al. (1992)

found that a 7% CHO-electrolyte beverage before and during a 40 km run significantly ($p<0.03$) improved the running performance during the last 5 km compared to a placebo drink. Chryssanthopoulos and Williams (1997) compared the time to fatigue in runners working at 70% of $VO_{2\ max.}$ They either consumed a pre-exercise CHO meal and a CHO-electrolyte drink during (M + C), a pre-exercise placebo and a CHO-electrolyte during (P + C), or a placebo both pre and during the run. The results showed that the M + C trial was significantly longer than the P + C and the P + P ($p<0.01$). The P + C was also significantly ($p<0.05$) longer than the P + P trial. Millard-Stafford et al. (1997) reported that a 6% and 8% CHO-electrolyte solution improved the final 1.6 km of a 15 km run by 14 and 18 seconds, respectively when compared to the water trial. This is roughly a 5% increase in high-intensity running.

Effects on high intensity intermittent activity and team sports

The evidence describing the effects of CHO before and during exercise with short bouts of high-intensity is less certain. Although several studies have not shown CHO to benefit high intensity exercise, there are plenty that do show an enhanced performance. For example, Murray et al. (1987) conducted an experiment where 13 subjects completed four separate trials, which consisted of steady state (55-65% VO_{2max}) cycling with two brief high-intensity performance rides. During the trial, the subjects consumed a water placebo or a CHO solution (5% glucose polymer; 6% sucrose/glucose; or 7% glucose polymer/fructose). All three CHO trials were significantly faster than the placebo trial with the fructose solution having the best time (375 s) to complete the 480 revolution cycling performance (sucrose trial = 384 s, glucose polymer trial = 401 s, and placebo trial = 432 s). Coggan and Coyle (1988) investigated the use of CHO feedings during prolonged cycling that included 15 minutes of alternating intensity (~60- ~80 % of $VO_{2\ max}$). Subjects consumed either a sweet placebo or a CHO solution after the first 10 minutes and then every 30 minutes thereafter. Fatigue was determined when the subjects could no longer exercise at 60 % of their VO_{2max}. Nineteen percent more work was completed during the CHO trial. After the third hour, the cyclists' $VO_{2\ max}$ dropped from ~85% to ~75%, which means that the higher intensity was unable to be sustained in the latter stages of prolonged intense exercise.

Ball et al. (1995) reported that the ingestion of a 7% CHO beverage during 50 minutes of high intensity cycling increased ($p<0.01$) peak power, mean power, and minimum power in the final all-out 30-second effort. Davis et al. (1997) investigated the use of an 18% CHO solution before and a 6% CHO solution during intermittent, high intensity cycling. The protocol included 1-minute of cycling at 120-130% of $VO_{2\ max}$ followed by 3 minutes of rest, which lasted until the 1-minute bout could not be completed. The researchers found that the CHO solution delayed fatigue ~ 27 minutes. Sugiura and Kobayashi (1998) tested the effects of fructose (F), glucose (G), and placebo (P) solutions on sprint performance after either continuous (CON) or intermittent (INT) exercise. Subjects performed three trials where they cycled for 90 minutes at 76% of $VO_{2\ max}$ (CON) and three more trials where they alternated between 65% and 100% of VO_{2max} (INT). Ingestion either of the F, G, or P occurred after 45 minutes of the cycling trial. At the end of each trial, the subjects completed a 40-second test to determine remaining sprint capacity. After testing the fatigue rate and the peak, mean, and minimum power from the 40 second test, results show that both G and F significantly {($p<0.001$) and ($p<0.01$), respectively} increased the mean power during the CON trial. However, only the G significantly ($p<0.01$) enhanced the performance of the peak and minimum power during CON when compared to P, and G also significantly improved mean power during INT (above both F and P).

Vergauwen et al. (1998) investigated the effects of CHO on stroke performance in tennis. Results showed that CHO before and during improved the performance of post-test shuttle times ($p<0.05$) and decreased the deterioration of stroke quality for first service and defensive rallies ($p<0.05$). The increase in error rate and non-reached balls was less during the CHO trial ($p<0.05$).

Team sports such as soccer, football, and field hockey include rapid increases of intensity interspersed with low intensity work for an extended period of time. Criswell et al. (1991) failed to show sports drinks having an effect for 8 successive 40-yard timed sprints after a 50-minute football game. Yet, Kreider et al. (1995) found field hockey players consuming a sports drink had a greater change in time to maximal exhaustion during pre and post aerobic testing and reported less post practice psychological fatigue in their seven days of intense training.

CHO and soccer performance

Several studies look at CHO use and the performance during a soccer match. Bangsbo et al. (1992) used soccer players as subjects while determining the effects of CHO on prolonged, intermittent exercise. The experimental trials, which consisted of a 46 minute standardized field test followed by a run to exhaustion on a treadmill, were created to emulate the running patterns of a soccer game. It included an 18-minute warm up (low and moderate speed running and stretching) and two 14-minute interval periods (standing; walking; jogging; low, moderate, and high speed running; backwards running; and sprinting). After the field test, the subjects ran on the treadmill for 35 minutes at 8 different speeds. Then the subjects alternated between high speed running for 15 s and low speed running for 10 seconds. Fatigue was determined when the subject could no longer run at the high intensity for 15 seconds. During the two days prior to each trial, the subjects consumed either a low (39%) or a high CHO diet (65%). The subjects ran 17.1 km after the high CHO diet, which was an increase of 0.9 km compared to the low CHO diet. Therefore, a high CHO diet enhanced performance during intermittent exercise.

Leatt and Jacobs (1989) determined the muscle glycogen use during a soccer match while players consumed either a 7% glucose polymer solution (ET) or a placebo (CT). Muscle biopsies were taken both before and after the game to measure glycogen levels. Pre-game glycogen concentrations were similar for both groups, but there was significant decrease in the CT after the game. This measurement showed a 39% decrease in glycogen utilization while consuming CHO before and during a match.

Balsom et al. (1999) examined the effects of CHO on the movement and technical parameters during a soccer match. On two occasions, the subjects participated in a 90-minute soccer game that was filmed for review of running patterns (rest, jogging, high intensity running, and pressuring the ball) and ball skills (number of ball touches and successful and high risk passes). Two days before each trial, the subjects performed a strenuous exercise protocol to lower muscle glycogen stores and then ate either a high (65%) CHO or a low (30%) CHO diet for 48 hours. The results showed a significant ($p<0.05$) increase in the amount of high intensity running and amount of time pressuring the ball after the high CHO diet. However, there was no significant difference in the technical parameters between the two diet regimens.

Muckle (1973) looked at glucose syrup (GS) ingestion and team performance, which was judged by the number of goals scored or conceded during a season. The players received GS before and during all twenty games during the first half of the season, and the last 20 matches served as the control. There was an increase in goals scored as well as a reduction in goals conceded in the second half during the GS trial. Only one goal was conceded in the final thirty minutes of play during the GS trial as opposed to the 12 for the control trial. During the control trial, scoring efforts fell ~50% in the last fifteen minutes of the game. During the final thirty minutes of play, a 20-50% reduction in the number of ball contacts was apparent when the players did not receive the glucose.

The previous studies show that CHO benefits a soccer player during a match, yet it is less clear whether or not the improved performance is due to enhanced motor skills or just increased running ability. A couple of studies have investigated CHO use and the performance of basic soccer skills. In Zeederberg et al's. (1996) experiment, two rival soccer teams met on two separate occasions to play against each other. Before the game and at half time, five players from each team received a 6.9% glucose polymer (GP) solution (Energade Sports Drink) while the remaining five players from each team received a placebo (P). The alternate beverage was consumed for the following game. The use of videotape aided the researchers in evaluating the performance of skills such as dribbling, heading, tackling, shooting, and passing. The GP consumption had no significant benefit on any other the above motor skills. However, glycogen content was not measured, and the evaluation of these skills was quite subjective with many uncontrolled variables.

Similarly, Abt et al. (1998) examined the effect of a high (80%) CHO diet compared to a mixed diet (40% CHO) on the skill performance after intermittent running on a treadmill. Before each trial, subjects completed a 60-minute intermittent treadmill exercise to deplete glycogen. For the next 48 hours, half of the subjects ate the high CHO diet while the other half ate the mixed diet. The trial consisted of 8 minutes of treadmill running at 50% of $VO2_{max,}$ a functional performance (dribbling and shooting) pre-test, a 1-hour intermittent treadmill exercise, and then same functional test again. The results showed that there was no significant difference in shooting accuracy for either dietary regimen, but there was a significant ($p<0.05$) decrease in the time to complete the functional test for the high CHO diet. Since skill performance was not decreased for the lower CHO amount, the authors concluded that muscle glycogen depletion might not hinder skill performance. Even though some researchers did not find CHO to effect technical skills, using objective tests without opposition as a variable may increase the chances of CHO improving skill performance.

Hydration effects

Since water makes up roughly 60% of the body's mass, it plays an important role in cardiovascular function and thermal regulation. During exercise, a person produces heat, which creates a rise in central body temperature. Consequently, the blood flow is increased to transport this heat from the working muscles to the skin where sweating is initiated helping to dissipate heat into the environment. Blood also is necessary to deliver oxygen and nutrients to the working muscles; therefore, inadequate blood supply to the muscles may limit performance (Lamb and Shehata, 1999)

If an individual loses a great amount of fluid without replacing it, then they will become dehydrated. Reilly (1996) reported that fluid loss in elite soccer player's average between 1-2 L and can reach up to 3 L during extreme conditions. When exercising in a dehydrated state, an athlete may experience several adverse effects, such as decreases in blood volume, stroke volume, cardiac output and increases in body core temperature and heart rate. These changes in the body may cause both performance deterioration and heat illnesses. The decrease in blood volume leads to excessive heat storage, which, in turn, affects its ability to produce sweat (Mack and Bergeron, 1996; Hargreaves et al., 1996; Fallowfield et al., 1996). Heat illnesses, such as cramps, exhaustion, heat stroke, and possibly even death can occur from the insufficient ability to dissipate heat. Convertino et al. (1996) stated that if an athlete begins in a hypo-hydrated state, their performance in high power, short duration exercise and prolonged exercise might be impaired.

In order to enhance performance or prevent these problems from occurring during exercise, proper fluid replacement is important especially for exercise in the heat and/or for events longer in duration or of higher intensity. Fallowfield et al. (1996) determined that when the subjects consumed water during a treadmill running exercise at 70% of VO_{2max}, they were able to perform significantly ($p<0.01$) longer than when consuming no fluid. Hargreaves et al. (1996) examined the effects fluid ingestion on muscle metabolism during 120 minutes of cycling at 65% of VO_{2max}. The results showed that the muscle glycogen was higher ($p<0.05$) and the muscle lactate was lower ($p<0.05$) after consuming 5 ml/kg of body weight throughout the trials. The researchers concluded that fluid ingestion reduced the glycogen utilization, thereby possibly improving performance during prolonged exercise.

McGregor et al. (1999) investigated the performance of a soccer skill after consuming fluid or abstaining from fluid. Elite soccer players performed a soccer skill test (dribbling) before and after a 90-minute intermittent exercise protocol, which was created to imitate the running patterns during a match. They found that when elite athletes consumed fluid during intermittent exercise, they experienced less deterioration of skills when compared to the no fluid trial ($p<0.05$). Nonetheless, too much fluid at one time can lead to stomach fullness, so consumption should be in small, frequent doses. Also, thirst is not a proper indicator of when and how much to drink because it is stimulated after dehydration has already occurred. Unfortunately, research investigating fluid importance for events less than one hour is somewhat controversial.

It is also important to note that sweat not only contains water but also several essential electrolytes, such as sodium, potassium, and chloride. Convertino et al. (1996) noted that the disturbances in water and electrolyte balance may hinder systemic and cellular function hence decreasing the ability to tolerate prolonged exercise. The concentration of electrolytes lost in the sweat depends on the individual's training level, heat acclimation state as well as sweat rate. The well-trained athlete tends to have a lower concentration of electrolytes per liter of sweat (Gislofi and Duchman, 1992; and Hawley et al., 1994). Sweat rates also vary among individuals, but obviously, there is a direct relationship between the amount of sweat produced and the work intensity, duration, and environmental temperature. The effects of replacing sodium in fluids are controversial. Although there is a large amount of sodium lost during exercise in the heat, people consume plenty of sodium in their diet that is sufficient for the majority of events (Convertino et al., 1996). Barr, Costill, and Fink (1991) determined the need of sodium replacement during prolonged exercise by comparing water (W), saline (S), or no fluid (NF) ingestion. The subjects exercised at 55% of $VO_{2\ max}$ until their plasma sodium was $\leq$ 130mmol/l. The plasma sodium, heart rate, and rate of perceived exertion were significantly ($p<0.001$) lower in the W and S trials. The differences between the W and S trials were not significant and no subject had to terminate the trial due to low levels of sodium, but the subjects in the NF trial rode 1.5 hours less than the subjects in both the W and S trials. Therefore, the authors suggest that fluid ingestion is important during prolonged exercise, but a need for sodium replacement in events less than 6 hours is unnecessary.

Considering that soccer lasts less than 2 hours, the main concern for adding sodium to fluid would be to increase palatability. Wilk and Bar-Or (1996) investigated the effects unflavored water (W), grape flavored water (FW), and grape-flavored water plus 6% of CHO and 18 mmol/l of NaCl (CNa) on young boys exercising intermittently in the heat. After drinking ad libitum for all three trials, the subjects consumed significantly more fluid during the CNa trial (which prevented dehydration) than the W trial (91%) and the FW trial (44.5 %). As far as taste perception, the subjects could not differentiate between the FW and CNa, but preferred them both more than plain water. On the other hand, Wilmore et al. (1997) found that the fluid preference during a 90 minute run at 60% of $VO_{2\ max}$ was not significantly different when comparing water, 6% CHO, and 8% CHO consumption. However, during the recovery, the subjects consumed 54% and 59% more CHO fluid than plain water.

Sports drinks

A common manner in which athletes replace their fluid is through the consumption of sports drinks. One of the main reasons sports drinks are popular among a wide variety of athletes is due to their palatability. Johnson et al. (1988) compared three commercial sports drinks and water during 4 hours of running and cycling. All of the CHO solutions increased the respiratory exchange ratio (significant for only two), whereas the time to exhaustion was unaffected by any of the fluids ingested. The researchers concluded that these commercial sports drinks increased voluntary fluid intakes.

Not only do sports drinks have a preferred taste from the added electrolytes, but they also are a source of CHO. As previously noted, CHO supplementation has been found to delay fatigue;

therefore, manufacturers argue that sports drinks enhance performance during intermittent, high intensity and/or prolonged exercise. Overall, sports drinks are said to replace sweat loss, reduce problems associated with dehydration, and supply CHO, which could enhance performance especially when initial glycogen stores are limited. However, there is not much evidence that supports their effectiveness when glycogen stores are sufficient (Coombes et al. 2000).

Many studies that do show positive effects while using CHO, however these solutions are not always equivalent to the contents of sports drinks. Coombes et al. (2000) reviewed over one hundred studies that tested the effectiveness of a CHO concentration similar to that of sports drinks. They stated that results depended on the test used to evaluate performance, the environmental conditions, and the training states of the individuals. A variety of research designs were employed throughout theses studies, such as controlling the pre-exercise glycogen status, the timing of ingestion, the composition of drink, and the rate of administration. The majority of the studies showed no effect when a lower CHO concentration was consumed before prolonged exercise, yet 14 of 26 studies showed improved performance when a less than 10% CHO solution was administered during prolonged exercise.

Davis et al. (1988) investigated the use of Gatorade™ during 2 hours of cycling and found improved performance during the subsequent 30-minute test ride. Only a few other studies examined the effects of current sports drinks on performance. Millard-Stafford et al. (1997) reported improved performance with Powerade™ and

Gatorade™ (over water) during the final sprint phase of a prolonged run. Ball et al. (1995) found Gatorade™ to enhance performance during short term intense cycling. And, Murray et al. (1991) used 6% (Gatorade™), 12% and 18% CHO during prolonged intermittent exercise and found both 6% and 18% to be beneficial. On the other hand, Flynn et al. (1987) reported no improvement with a high CHO solution (Exceed™). Coombes et al. (2000) concluded that sports drinks consumed during intense short-term, prolonged-intermittent, and prolonged exercise appear to improve performance. Still, little evidence supports the use of lower CHO (<10%) concentration before intense short-term and prolonged exercise to benefit performance.

Unfortunately, the evidence is somewhat limited and controversial when investigating the use of sports drinks during team sports activities. As previously cited, Criswell et al. (1991) found no effect while Kreider et al. (1995) did find an effect when using glucose solutions comparable to a sports drink. Leatt and Jacobs (1989) showed a 39% decrease in glycogen utilization while consuming 7% CHO solution. Yet, Zeederberg found no improvement in soccer skills with a 6.9% CHO (Energade). More research on the effects of sports drinks during team sports, particularly soccer, and their effects on children in any type of activity is necessary, especially since young soccer players make up a large amount of athletes consuming these products with the belief that they have ergogenic effects.

Sports Drink (per 250 ml or ~8 oz)	Energy (kcal)	Na (mg)	K (mg)	Cl (mg)	Total CHO (g)	[CHO] (%)	Osmolality (mOsm/kg)
All-Sport	80	55	55	*	21	8.4	*
Exceed	70	50	45	80	17	6.8	250
Gatorade	63	103	30	1	15	6.0	320-360
Powerade	70	70	30	*	19	7.6	*
10 K	60	55	30	*	15	6.0	350

*Not stated

Table 1: Comparison of Contents in Popular Sports drinks

Youth Demands

Having evidence that fluids and CHO benefit elite soccer players, it is important to learn their effects on young athletes as well. Since young children are becoming serious competitors in many sports with soccer being the most popular, more and more people are wondering if these athletes will experience similar benefits of CHO use as their elite counterparts. Nevertheless, only limited researchers have investigated the activity profile and energy demands of young players. The few studies using children as subjects tend to focus on 11-12 year old boys. At this age, the game only lasts for 60 minutes rather than the full 90 minutes that adults play, but the children play on a full size field and still experience high levels of intense running along with numerous changes of activities that are of high caloric cost. Young players may exert similar amounts of energy due to their higher energy cost per kg of body mass when walking or running (Bar-Or and Unnithan, 1994).

While research on the exact caloric cost during a youth game is lacking, Klimt et al. (1992) showed that the average heart rate for an 11-12 year old boy during a soccer game is 160-180 beats/ minute, which is comparable to the elite athlete's heart rate (155-170 beats/minute). This illustrates the intermittent, high intensity pattern during a game.

The concentration of blood lactate differs between an elite athlete and a child during a soccer game. Klimt et al. (1992) and Bar-Or and Unnithan (1994) found blood lactate levels to be 3-4mM. By avoiding a major accumulation of lactate, more short sprints can be accomplished; therefore, allowing children to compete at higher intensities. Moreover, Hebestreit et al. (1993) found that recovery time for children is faster during short-term intense exercise.

Even though children have higher increases in core body temperatures, a child's sweat rates and Na concentrations are less than adults are (Bar-Or, 1994; Falk et al., 1992). And, Meyer et al. (1992) investigated the difference in sweat electrolyte loss between gender and maturation: prepubescent (PP), pubescent (P), and young adult (YA). Subjects cycled for two 20-minute bouts at 50% of $VO_{2\ max}$ where sweat was collected and analyzed. Sweat [K] was lower in YA while the [Na] and [Cl] in sweat appeared to increase with maturation. The sweat rate was lower for the children than the YA, thereby having higher Na and Cl losses. Also, there were no gender differences in any of the electrolyte losses in PP and P.

Researchers have investigated the importance of taste and fluid consumption for children exercising in the heat. Meyer et al. (1994) examined dehydration in children during 90 minutes of intermittent exercise in the heat. First, the subjects tasted four different drink flavors, both by knowing and not knowing their color. The results showed that they significantly ($p<0.05$)

preferred the grape more than the apple and water whether or not they saw the color and significantly ($p<0.05$) preferred the taste of grape more than orange when they did not see the color. Next, the subjects met on four occasions where they exercised for three 15-minute periods with interspersed 15-minutes rest periods. After the dehydration period, the researchers measured the amount of the assigned beverage that was consumed ad libitum in 30-minutes. The results show that the subjects tended to over-hydrate for each of the drinks, however grape and orange was significantly ($p<0.05$) higher than apple and water.

Summary:

In conclusion, evidence suggests that, in elite males, CHO supplementation improves running performance and fluid intake prevents the deterioration of skills. Evidence also indicates that sports drinks contain enough CHO to improve performance in certain events and also tend to increase fluid increase due to the preferred taste over water. However, it is still unclear whether or not they can help during team sports such as soccer.

Millions of children participate in competitive soccer, and, just like their elite counterparts, they want to improve their performance. Unfortunately, limited studies use children as subjects when testing CHO effects. By using a beverage that is a popular choice and typically consumed before and during soccer games by many athletes, this study attempts to determine if a sports drink such as Gatorade will benefit a young soccer player.

CHAPTER III:

METHODOLOGY

Overall Design:

Ten male subjects were randomly selected from a group of 30 travel soccer players on the basis of competitiveness, work ethic and availability to participate in this experiment. They met on three separate occasions; the first of which was a familiarization trial and signing of consent/assent forms. The two experimental trials included a pre- and post exercise protocol and a 40-minute scrimmage where the subjects consumed 32 ounces of either a sports drink (Gatorade™) or a placebo (Crystal Light™). It was a double blind crossover design with the ten subjects randomly divided into two groups. A 2-way ANOVA with repeated measures was used to determine if there was a significant effect of treatment, time and/or their interaction.

Methods:

Subjects

Subjects consisted of 10 youth soccer players (n=10), 10 and 11 years of age. The average height and weight was 148.3 ± 20.4 cm and 37.3 ± 1.8 kg, respectively. Volunteers were selected from the Blacksburg area competitive soccer program. Because the experimental trial consisted of a competitive scrimmage and because there are considerably more boys' competitive soccer teams in the Blacksburg area, subjects were limited to males. The subject selection process included observation local travel teams and a random selection of highly motivated players who were capable of completing the exercise tests. Before approaching the selected players, the experimental protocol was explained to the prospective subject's parents first to see if they would allow their child to participate. Once parental permission was received, the child's permission was obtained.

Procedures

In this study, the subject was expected to meet at Cassell Coliseum (on the Virginia Tech campus) on three separate occasions for two hours within a three-week period. Using an indoor facility eliminates environmental variables (temperature, weather, and field conditions). The first session consisted of signing the informed consent and assent forms, answering medical history questionnaires and obtaining height and weight. Explanations of the risks, benefits, confidentiality, and the subject's responsibilities were discussed. Instructions and food record sheets for both trial dates were provided and explained. In addition, subjects familiarized themselves with the test protocol. The second and third sessions consisted of the experimental trials.

The 10 subjects were randomly divided into two teams and remained on that specific team for both trials. All of the players on team A received the same treatment, as did the players on Team B. Each player was randomly paired with a player from the opposite team and worked alongside this partner for all of the exercise protocols. The partners worked with the same timer at the same testing location for the entire experiment. For Trial 1, each player on Team A was given the sports drink (Gatorade™) while the players on Team B were given the placebo (Crystal Light™). For Trial 2, the players received the alternate treatment.

Experimental Trials

Each experimental trial consisted of a warm-up and stretch period, a pre-test protocol, two 20-minute scrimmage periods (separated by a 5 minute rest period), and a post-test protocol. At the beginning of each trial, the subjects consumed 8 oz of fluid. Between each change of activity, they consumed an additional 6-oz of fluid. Total fluid consumption was 32oz in order to ingest optimal fluid and CHO amounts.

The warm-up was fifteen minutes where the subjects practiced the exercises of the test protocol and then stretched. The scrimmage was played on a 30 X 25 indoor court. The ten players were divided into two equal teams, so the game would remain competitive and intense in its entirety. With an indoor setting, there were no boundaries, which meant that the play was continuous. The temperature was also kept at a constant 75° F.

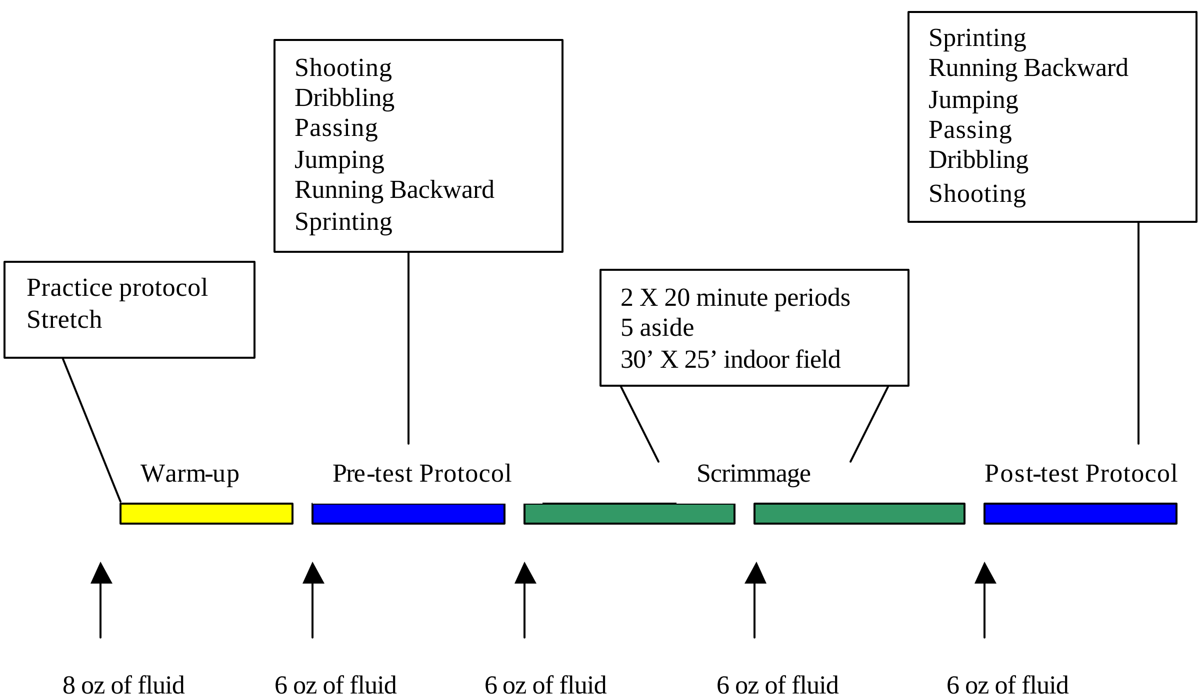

Figure 1. Occurrence of events during experimental trials

Test Protocol

The performance pre-test protocol included six activities to measure skills, agility, power, and speed. 1) *Shooting*: A soccer shot was taken 4 yards in front of a goal. Each player took two turns shooting the ball into the goal. One of the investigators was standing behind the net with a Juggs Radar Gun and measured the subject's shot velocity. 2) D*ribbling:* This pattern included a player standing on the right side of a cone and sprint dribbling to the left side of the cone 10 yards ahead. The subject dribbled around the cone and returned to the start cone on the opposite side (one repetition). Five repetitions were timed. 3) *Passing:* The subject stood 1 yard away from a wall and used the inside of his foot to pass the ball. The investigator recorded the time to complete 20 passes against the wall. The pass did not count if the subject passed it in front of the line. 4) *Jumping:* The subject jumped side to side over a 4-inch cone. The investigator counted the number of jumps in 30 seconds. If the jump was not over the cone it did not count. 5) *Shuttles:* This included sprinting to a cone 10-yards away, going around it, and then sprinting backward to start cone (one repetition). The subject did 6 repetitions timed. 6) *Sprint:* This included a timed 40-yard dash in which the subject ran against a partner. The dribbling, passing, jumping and shuttle activities had five timers with their two randomly assigned subjects. So, there were five total subjects being tested at a time while five were resting. Once the first subject finished his one exercise, the partner was then tested. When they completed that exercise, they quickly began the next exercise. Their order remained the same for the entire experiment. For the 40-yard dash, only two investigators timed (one timer for each sprinter). The sprinting order, racing partners, and timers remained the same throughout the experiment. The post-test involved these same six exercises but in reverse order.

Dietary Intake

On the day of each trial, the subjects were asked to follow their typical dietary habits and kept a food record. They also were asked to refrain from eating anything two hours prior to the trials. For the second trial, the subjects were asked to use their previous food record and consume similar foods and drinks. Again, they were asked to fast two hours prior to the experiment.

Statistical Analysis

A two-way analysis of variance with repeated measures was used to analyze the effects of treatment, time and/or their interaction. The data are expressed as means $\pm$ standard deviation. The level of significance used to reject the null hypothesis was $p < 0.05$.

Subject's Responsibilities

The subjects were asked to give maximal effort during the exercise. The level of exertions during the experimental trials were comparable to that regularly attained during a typical soccer practice or competitive game. Thus, the risk of injury was no greater than that typically experienced by youth soccer players. No subject was injured, and all finished the experiment. Subjects were also expected to observe the following responsibilities: record food eaten on the days of the trials; refrain from food 2 hours prior to each trial; and eat similar meals and snacks on both days of the trials.

Benefits

This study attempted to determine if consumption of sports drinks improve precise motor skills, speed, agility, and power during a soccer game. Because these beverages are so widely used among young athletes, it is imperative that their effects (or lack thereof) are known. Such information may greatly benefit young athletes who compete at intense levels for a prolonged period of time. In addition, it will provide parents with much needed information about the use of these beverages.

Confidentiality

While confidentiality of results was maintained, participants could inquire about their individual performance scores. Thus, each subject had to opportunity to benefit from knowledge of his or her soccer ability. The subject was identified by code and individual results obtained from the test protocol are completely confidential. However, overall results of the study are available to the public.

CHAPTER IV:

RESULTS

Reliability of Exercise Tests:

Table 2 shows the reliability of the exercise tests. These results are from trials administered on separate days. Percent error was calculated as %E = |T1 – T2| ÷ X • 100%, where T1 and T2 are values for Trial 1 and Trial 2 and X is the mean. As can be seen, the percent error between trials is below 6% for all tests except the passing. This indicates that these tests are reliable and can be reproduced. The passing parameter may have an increased variability possibly due to the fact that young players may be less familiar with this type of passing activity, where as, they have performed the other five parameters during their regular team practice on several occasions.

	Trial 1	Trial 2	Error (%)
Shooting ***(mph)***	38.3 ± 0.9	38.8 ± 01.0	2.9 ± 1.1
Dribbling ***(s)***	46.78 ± 1.27	47.25 ± 1.37	2.7 ± 1.3
Passing ***(s)***	18.71 ± 1.09	19.12 ± 1.61	15.0 ± 4.2
Jumping ***(#)***	54.5 ± 2.7	55.25 ± 2.0	5.4 ± 1.2
Backward ***(s)***	43.65 ± 0.76	44.03 ± 0.55	5.5 ± 1.1
Sprinting ***(s)***	6.33 ± 0.09	6.22 ± 0.09	3.2 ± 1.0

Table 2. Percent error between trials - shows reproducibility of exercise tests. Trial values are means ± SE.

Effects of Sports Drinks on Motor Skills, Agility, Power, and Speed:

Shot Velocity

The shot velocity was affected by the consumption of the sports drink, Gatorade. There was a significant decrease ($p<0.01$) in the mean shot velocity from pre to post during the placebo trial while it did not decrease during the Gatorade trial. The range of the subject's shot velocity before the scrimmage was 33.5 to 44 mph. This indicates that the group was fairly similar in shooting ability.

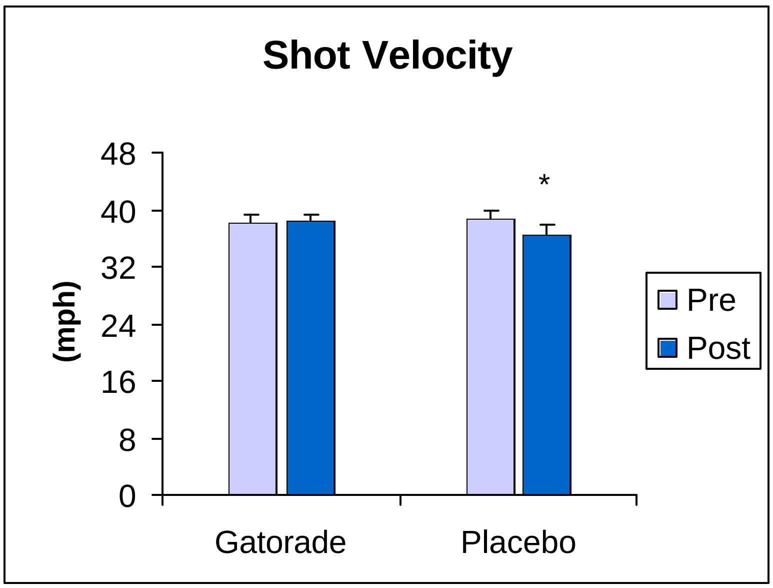

Figure 2. Effects of Gatorade and/or scrimmage on shot velocity (* $p < 0.01$)

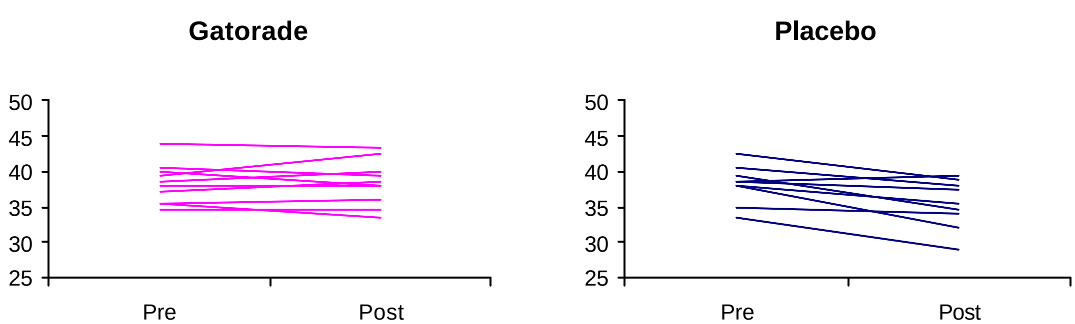

Figure 3. Shot velocity trends for each subject during the trials

Dribbling

The range of the dribbling times during the pre-tests was 43.56 - 57.38 seconds (13.82 s). The difference in the subject's ability to speed dribble with control was moderately varied. This dissimilarity is typical for younger players.

The consumption of Gatorade had no significant effect on the time to complete the dribbling exercise at either the pre or post measuring period. When comparing the pre and post values, both the Gatorade and placebo trials had a slight increase the mean dribbling time. However, it was not significantly different.

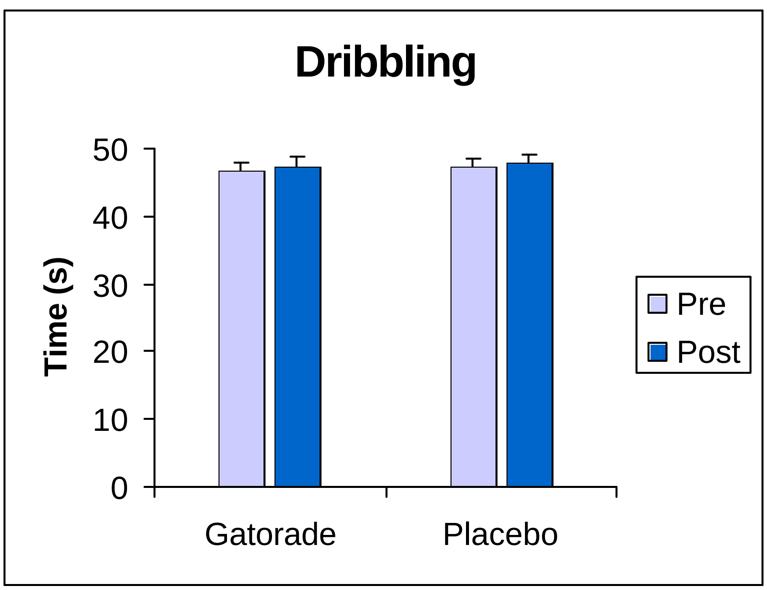

Figure 4. Effects of Gatorade and/or scrimmage on dribbling performance

Passing

The range of the passing times during the pre-tests was 14.09 to 30.61 seconds (16.52 s). This exercise test had a large variation. Possibly due to the fact that many of the subjects had rarely practiced passing the ball quickly against a wall prior to this experiment, where as they have executed all of the other activities many times.

As far as the effect of Gatorade and/or the scrimmage on their performance, there were no significant differences. The consumption of Gatorade had no significant effect on the time to complete the passing exercise at either the pre or post measuring period. When comparing the pre and post values, the mean passing time for the Gatorade trial tended to increase slightly, while the placebo trial showed a decreasing trend. But again, these values were not significantly different.

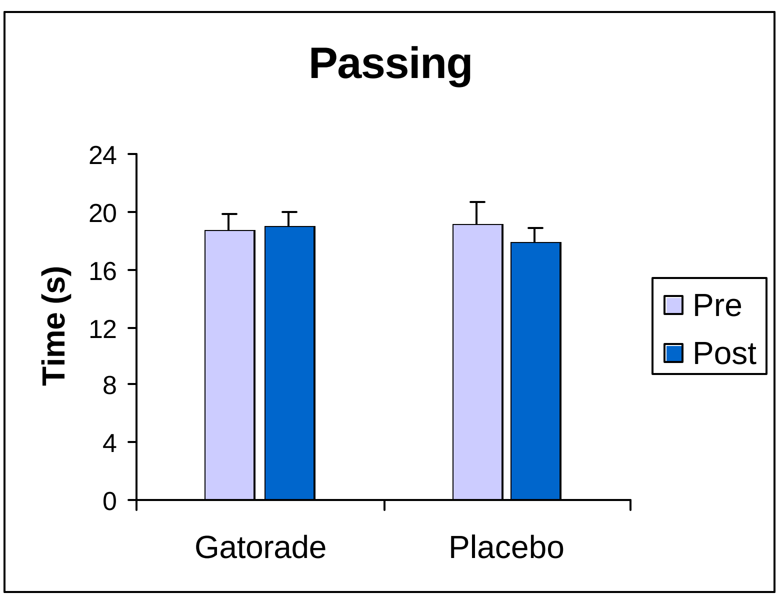

Figure 5. Effects of Gatorade and/or scrimmage on passing performance

Jumping

The range of the number of jumps in 30 seconds during the pre-tests was 37 to 64 jumps (27 jumps). When excluding the one subject whose jumps were much lower than the other subjects, the range was much closer; 48 to 64 jumps (16).

The consumption of Gatorade did not have a significant effect on the jumping exercise at either the pre or post measuring period. Nevertheless, the number of jumps completed during the post test was significantly lower ($p < 0.05$) than the pre test for both treatments.

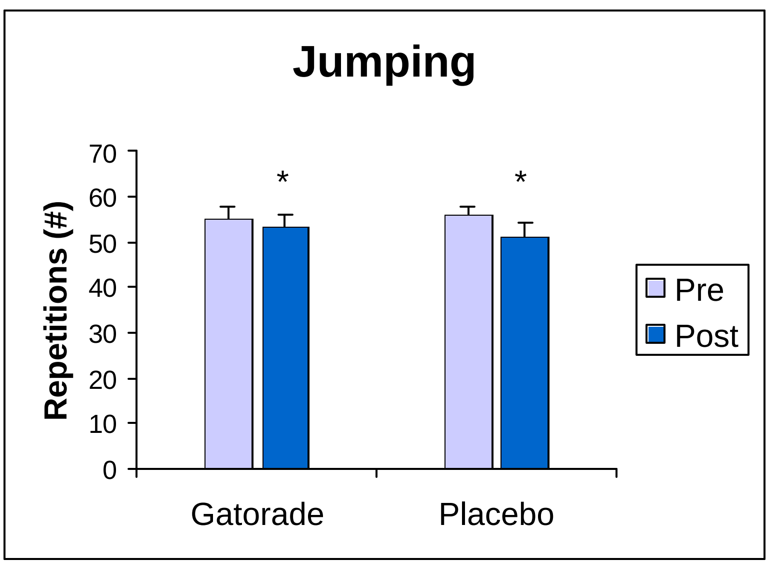

Figure 6. Effects of Gatorade and/or scrimmage on jumping ability (* p <0.05)

Backward Running

The range of the backward running times during the pre-tests was 39.44 to 46.72 seconds (7.28 s). This indicates the group was reasonably homogeneous in backward running ability.

Although the values after the scrimmage increased more during the placebo trial than the Gatorade trial, the difference was not significant. The consumption of Gatorade did not have a significant effect on the backward running time for either the pre or post-test measuring period.

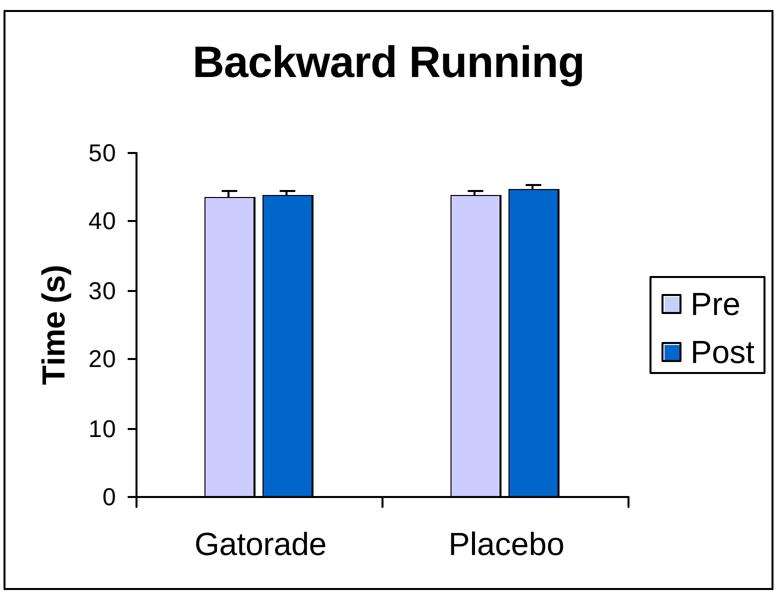

Figure 7. Effects of Gatorade and/or scrimmage on backward running time

40 yard Sprint

The range of the 40-yard sprint times during the pre-tests was 5.52 to 6.76 seconds (1.24s). Again, this difference indicates that the variation in the subject's sprint performance is fairly consistent and typical of young soccer players.

The consumption of Gatorade did not have a significant effect on the 40-yard sprint time during either the pre or post-test measuring period. Also, neither treatment showed a significant difference in the time to complete the 40-yard sprint when comparing the sprint times before and after the scrimmage.

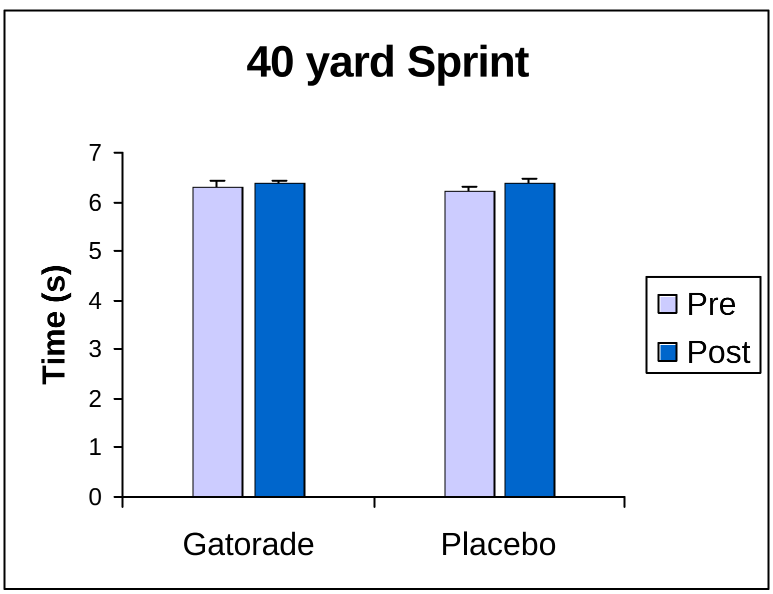

Figure 8. Effects of Gatorade and/or scrimmage on 40-yard sprint time

CHAPTER V:

DISCUSSION

General Discussion:

Purpose

The present study is the only research to the investigator's knowledge that examined the effects of a sports drink on the performance of a young soccer player (where young is defined as 10 and 11 years of age). Other researchers have completed similar studies on elite soccer players, however they usually used high CHO diet or glucose syrup as a treatment with an extended fast prior to the trial. The purpose of this investigation was to find the effects of a widely consumed beverage without altering the subject's typical dietary routine; the subjects fasted for a shorter, more practical length prior to a competition as well as followed their normal dietary habits.

The parameters measured in this investigation were basic skills and activities that are performed many times throughout a game. Some researchers in earlier studies evaluated the performance of similar technical parameters such as dribbling and passing, only they evaluated skills performed in a game situation. Even though a game is a realistic setting, examining skill (i.e. determining performance on the basis of successful shooting, passing or dribbling attempts) while playing against opponents is more subjective and creates unwanted variables. Therefore, in order to eliminate those external variables, the subject's performance was measured individually against an electronic stopwatch to measure the time to complete the dribbling, passing, jumping, backward running, and sprinting tests and radar gun to determine their shot velocity. Abt et al.'s (1998) experiment was similar to this current study in that they also measured the time to complete a dribbling pattern and evaluated the subject's shooting performance both before and after an exhaustive exercise test. The studies differed in that this study measured four other parameters and used a scrimmage to deplete glycogen stores instead of a treadmill test.

Like Balsom and colleague's (1999) research, this experiment also occurred indoors. The decision to use an indoor facility was based on the ability to control more variables, such as temperature and field conditions as well as create a warmer climate since the experiment was conducted during the winter. The temperature was set at 75^o Fahrenheit. The indoor arena also provided an intense atmosphere where the play was quite fast and continuous. Players rarely stood still since the use of walls eliminated boundaries and stoppage of play. The smaller space meant that all players would be "one pass away"; therefore, they needed to stay involved at all times. Since playing indoors tends to be more exhaustive than an outdoor game, the scrimmage was decreased from the two 30-minute halves usually played at this age to two 20-minutes halves. Unfortunately, by using an indoor court, the floor was more slippery than the outdoor surface, and the subjects were not as familiar with playing on an indoor court, thereby possibly creating more variation in some of the test measurements. Less variation may have occurred on a grass field.

One final note on the design of the experiment is necessary. During the post-test, the order in which exercise tests were performed was reversed. The reversed order was conducted by reason of wanting to increase the amount of time between the tests that measured skill performance (those activities performed with a ball).

Findings

The main finding of the present investigation showed that the interaction of the scrimmage and the consumption of 32 ounces of Gatorade did affect the shot velocity. While the shot velocity decreased after the scrimmage for the placebo treatment, it did not change during the Gatorade treatment. By using ANOVA with repeated measures, a significant effect of $p < 0.01$ was calculated. Eight of the subjects decreased their shot velocity (5 of them by 2.5 or more) under the placebo condition; moreover seven remained constant or increased their shot velocity under the Gatorade condition. Therefore, the null hypothesis for the shot velocity was rejected due to the interaction of the Gatorade consumption and the scrimmage.

The study also showed a scrimmage effect on the jumping parameter. The number of jumps performed after the scrimmage significantly ($p < 0.05$) decreased compared to the jumps before the scrimmage for both treatments. Seven decreased under the placebo condition (5 subjects by 6 or more jumps). And, six decreased under the Gatorade condition (2 subjects by 6 or more jumps). Therefore the null hypothesis for jumping performance was rejected due to the effect of the 40-minute scrimmage.

The consumption of 32 ounces of Gatorade, the 40-minute scrimmage and/or their interaction had no effect on the final four parameters: dribbling, passing, backward running, and sprinting. Even though the times to complete the dribbling, backward running and sprinting exercises were increased after the scrimmage for both treatments, the increases were slight and not significantly different.

Explanation

One of the reasons the Gatorade had an effect on the shot velocity may be due to the fact that it was the first exercise during the pre-test and the last during the post-test. This extra amount of work may have caused more depletion of glycogen stores allowing the Gatorade to have an effect. This is not similar to the findings of Abt et al. (1998). Even though their study measured the accuracy of shooting while the present investigation measured the velocity of a shot, both tests require the subject to use the same shooting technique which requires the same needs. Their research showed that shooting accuracy was not affected by the high CHO diet. They suggested that because a shot is a brief, more explosive movement, the ATP and PCr stores may be sufficient, thereby buffering the ATP requirement. On the other hand, the findings of this study differed with Abt and colleague's and showed that Gatorade consumption did in fact affect shot velocity. More research in this area needs to be completed.

The number of jumps decreasing for both treatments suggests a 40-minute scrimmage effect without a Gatorade effect. Since the trend was similar for both treatments, the decrease in performance may have been due to an alternative mechanism. The jumping exercise was quite exhaustive and required more energy than some of the other tests; therefore, more of an increase in lactate production may have accumulated. This increase lactate may have significantly affected the number of jumps the subject's were able to perform. Therefore, the decrease in the number of jumps both treatments suggest that either the 32 ounces of Gatorade did not provide sufficient CHO to improve performance or that the production of lactate was the cause for the decrease, not the depletion of glycogen stores.

The other four tests (passing, dribbling, backward running, and sprinting) were not affected by either the 32 ounces of Gatorade, the scrimmage, and/or their interaction. Nevertheless, the latter three tests did show a slight, but not significant, deterioration in performance due to the scrimmage. Increasing the number of subjects may allow for a significant scrimmage effect to occur.

Other reasons may explain why the Gatorade or the scrimmage did not show an effect on these four parameters. First of all, even though the subject's work rate throughout the exercise tests and the scrimmage was intense and impressive, the scrimmage may not have been exhaustive enough to deplete their glycogen stores and impair the subject's ability to perform these tasks. Increasing the length of the scrimmage or adding in long sprints throughout the scrimmage may have created a more exhaustive state for the subjects. However, altering the scrimmage would have defeated the purpose of trying to provide a typical game situation. Secondly, muscle glycogen stores may have been sufficient prior to the experimental trials (due to the subject's diet on the day of the trial or the short fast prior to the experimental trials). Coombes et al. (2000), as stated previously, compared numerous studies that examined the effects of sports drinks. They concluded that sports drinks do not affect performance when stores are sufficient. Sports drinks, however, have been proven to help athletes after a long fast or when glycogen stores have been depleted. A third possible reason that no effect was found may be due the fact that a child, during prolonged exercise, has an increased fat utilization, thereby allowing for less of a need for manipulation of glycogen stores. During prolonged activity, children were found to have significant increases in free glycerol levels in blood and have greater free fatty acid (FFA) uptake than adults (Bar-Or and Unnithan, 1994 and Berg and Keul, 1988). Although a game is interspersed with activity of an anaerobic nature and requires an increased use of glycogen stores, the majority of the game requires aerobic metabolism which utilizes both glycogen and lipid stores. As much as 40% of total energy needs during a soccer game can come from FFA oxidation with a greater amount in the second half (Bangsbo, 1994 and Shephard, 1999). Since children rely more on fat than CHO compared to adults during aerobic activities, CHO supplementation, such as Gatorade consumption, may not affect performance.

Lastly, an alternative mechanism, such as lactate production or dehydration and not muscle glycogen depletion, may be the cause of impaired skills. The increased production of lactate has been found to hinder technical abilities. Some researchers have suggested that skills are not impaired from the depletion of glycogen stores (Bangsbo et al. 1992; Abt et al. 1999; and Godik et al., 1993), and skill performance diminished with an increase in lactate production (Berger and Smith-Hale 1991; and Godik et al., 1993). Children have been found to have low levels of blood lactate accumulation throughout a soccer game (Klimt et al. 1992) and have a faster recovery time (Hebestreit et al. 1993), thereby indicating a possible reason why there is a lack of skill deterioration after the scrimmage. Not only might lactate production be a factor, but dehydration also has been found to hinder the performance of technical activities. McGregor and coworker's (1999) found that the trial in which subjects consumed water during the exercise trials had less deterioration of skills compared to the trial in which they abstained from fluid. The absence of a decrease in skill performance in the current study, may, in fact, be due to proper fluid replenishment during both treatments. Still, more research determining whether lactate acid, dehydration, and/or depletion of glycogen stores causes a decline in performance needs to be completed.

Conclusion:

For 10 and 11 year old competitive male soccer players, 32 ounces of Gatorade consumed during the trials, the 40-minute scrimmage, and/or their interaction did not effect motor skills, agility, or speed, which was measured by passing, dribbling, backward running, and sprinting tests. Since neither the Gatorade or the scrimmage affected these measures, it is speculated that 1) Muscle glycogen may not have been depleted enough, possibly because the prescribed exercise during the trial was not intense or long enough. 2) Muscle glycogen stores were sufficient prior to the experimental trials (due to the subject's diet on the day of the trial or the short fast prior to the experimental trials). 3) A child's increased fat utilization allows for less of a need for manipulation of glycogen stores. 4) An alternative mechanism, such as increased lactate production and not muscle glycogen depletion, may impair skills.

The scrimmage, however, did affect the jumping performance while the consumption of Gatorade did affect the shot velocity after the intense training for these particular subjects in this particular situation. More research should be performed to determine if these significant effects would occur repeatedly or if they were by chance.

Even though Gatorade had no performance effects, except on the shot velocity, on these young male soccer players in this current competitive training environment, the consumption of a sports drink may still have performance benefits in other situations. For example, researchers have proven that the preferred taste of sports drinks increases the amount of fluid intake (Johnson et al 1988; Wilk and Bar-Or, 1996; Wilmore et al., 1998). With the belief that dehydration hinders performance and more fluid is consumed due to the preferred taste of sports drinks, one might conclude that sports drinks indirectly might help improve performance.

Future Research:

More research examining the effects of sports drinks on young athletes needs to be conducted. The following are possibilities for future research.

1. Increasing the temperature of the gym or conducting the research outside on a hot day may create a scrimmage effect on these six parameters as well as giving Gatorade a greater likelihood of providing benefits.

2. Many soccer games played at the youth level are played in the morning. It is common for a player to wake up just prior to the game without having time to eat

a proper breakfast. Since this occurs often, doing an experiment that takes place in the morning and having the subjects refrain from eating prior to the trial may be another possible manner in which to determine if a sports drink will enhance the performance of a soccer player in a typical situation. The overnight fast may increase the chances of depleting glycogen stores.

3. All day camps/clinics, tournaments or multiple training/games in a day or weekend occur quite often throughout the year for soccer players. Due to the lack of time available or the avoidance of an upset stomach from food ingested too quickly before or after a game, many athletes prefer to consume fluids, such as sports drinks, or light snacks high in CHO to help them through the next match. Unfortunately it has yet to be determined if sports drinks replenish glycogen stores enough to enhance the performance of young soccer player during their subsequent game or training session. Thus, testing the effects of a sports drink on performance of young soccer players during a tournament/clinic situation would be beneficial.

4. As suggested earlier, adding more time or incorporating sprints into the scrimmage may create a more exhaustive state in order to increase the depletion of glycogen stores. This greater depletion may allow the consumption of Gatorade to have an effect.

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APPENDICES

Virginia Polytechnic Institute and State University

Informed Consent of Investigative Projects for Parent/Guardian of the Participants

Title of Project: The Effects of Sports Drinks on Soccer Skill Performance in Youth Soccer Players

Investigators: Kim Stewart and Jay Williams

I. The Purpose of this Research/Project

Sports drinks are popular among a wide variety of athletes. Not only do these drinks replace fluid lost during exercise, but they also are a source of carbohydrate (CHO). Since both fluid and CHO supplements are thought to delay fatigue, manufacturers argue that sports drinks enhance performance during prolonged exercise. Indeed, studies have found that CHO ingestion aids in the performance of elite soccer players. The effect is particularly evident when CHO is consumed prior to and/or during strenuous activity and measurements are made thereafter. Many of these studies use elite athletes and CHO concentration levels unrealistic to the everyday competitive athlete. This raises two questions. First, do sports drinks, which provide less CHO than used in previous studies, similarly affect soccer performance? Second, do young athletes benefit from consuming sports drinks before and during activity?

The purpose of this non-invasive study is to determine if sports drinks, will enhance the soccer skill performance of young soccer players. By using a readily consumed and easily available product, this study attempts to determine if sports drinks are an effective yet realistic CHO supplement for children in competitive sports.

II. Procedures

Subjects will consist of 10 youth soccer players between the ages of 10 and 12 years. Volunteers will be selected from the Blacksburg area competitive soccer program. Because the experimental trial will consist of a competitive scrimmage and because there are considerably more boys' competitive soccer teams in the Blacksburg area, subjects will be limited to males.

In this study, the subject is expected to meet at Cassell Coliseum (Virginia Tech campus) on three separate occasions for two hours within a three-week period. The first session will consist of signing of informed consent and assent forms and answering medical history questionnaires. In addition, subjects will familiarize themselves with the test protocol. The second and third sessions will consist of the experimental trials.

Each experimental trial will consist of a warm-up and stretch period, a pre-test protocol, two 20 minute scrimmage periods (separated by a 5 minute rest period), and a post-test protocol.

The pre- test protocol will include:

- 2 soccer shots where ball speed will be recorded.
- 5 “Figure 8” dribbling patterns where completion time will be recorded.
- 20 passes against a wall where completion time will be recorded.
- 30 seconds of side-to-side hoping over the ball where repetitions will be recorded.
- 6 timed shuttles runs- Sprint forward 10 yards- return running backwards
- 40 yard sprint where completion time will be recorded.

The post-test will be the same exercises but in reverse order.

At the beginning of each trial, the subjects will consume 8 oz of fluid. Between each change of activity, they will consume an additional 6 oz of fluid. Total fluid consumption will be 32oz. For trial 1, half of the subjects will receive Gatorade™ while the other half will receive a placebo (Crystal Light™). For trial 2, the treatments will be reversed.

III. Risks and Efforts to Minimize Risks

The subjects will be asked to give maximal effort during the exercise. As such there is a risk of injury including sprains, muscle strains, contusions, lacerations and fractures or other complications including dizziness, fainting and sudden death. However, the level of exertions during the experimental trials are comparable to that regularly attained during a typical soccer practice or competitive game. Thus, the risk of injury is no greater than that typically experienced by youth soccer players. Trained youth soccer coaches and athletic trainers will observe all sessions to identify players who appear to be at risk. Also, communication to emergency medical personnel will be available.

IV. Benefits of this Project

This study attempts to determine if consumption of sports drinks improve precise motor skills, speed, agility, and power during a soccer game. Because these beverages are so widely used among young athletes, it is imperative that their effects (or lack thereof) are known. Such information will greatly benefit young athletes who compete at intense levels for a prolonged period of time. In addition, it will provide parents with much needed information about the use of these beverages.

While confidentiality of results will be maintained, participants can inquire about their individual performance scores. Thus, each subject has to opportunity to benefit from knowledge of his or her soccer ability.

V. Extent of Anonymity and Confidentiality

Subject will be identified by code and individual results obtained from the test protocol will be completely confidential. However, overall results of the study will be available to the public.

VI. Compensation

Subjects receive no compensation for their participation in this project.

VII. Freedom to Withdraw

Subjects may withdraw from this study at any time with no penalty. They are also free not to answer any questions or respond to any experimental situations that they choose with no penalty.

Parents will be permitted to observe this project and may withdraw their child at any time without penalty.

VIII. Approval of Research

This research project has been approved by the Institutional Review Board for Research Involving Human subjects at Virginia Polytechnic Institute and State University and the Department of Human Nutrition, Foods and Exercise.

IX. Subject's Responsibilities

Subjects are expected to observe the following responsibilities:

1. Complete a Medical History questionnaire
2. Perform both trials to the best of his ability
3. Record food eaten on the days of the trials
4. Refrain from food 2 hours prior to each trial

5. Eat similar meals and snacks on both days of the trials

X. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all of my questions answered. I hereby acknowledge the above and give my voluntary consent for my child to participate in this project. I agree to abide by the subject responsibilities listed above.

If my child participates, I understand that I may withdraw him/her at any time without penalty.

______________________________ ________________________

Signature Date

______________________________ ________________________

Witness Date

Should I have any questions about this research or its conduct, I may contact:

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Virginia Polytechnic Institute and State University

Informed Assent For Participants of Investigative Projects

Title of Project: The Effects of Sports Drinks on Soccer Skill Performance in Youth Soccer Players

Investigators: Kim Stewart and Jay Williams

I. The Purpose of this Research/Project

Sports drinks are popular among a wide variety of athletes. Manufacturers argue that sports drinks enhance performance during prolonged exercise. Indeed, studies have found that CHO ingestion does aid in the performance of soccer players, but many of these studies use elite athletes and CHO concentration levels unrealistic to the everyday competitive athlete. This raises two questions. First, do sports drinks, which provide less CHO than used in previous studies, similarly affect soccer performance? Second, do young athletes benefit from consuming sports drinks before and during activity?

The purpose of this study is to determine if sports drinks, such as Gatorade, will enhance skill and running performance of young soccer players. By using a readily consumed and easily available product, this study attempts to determine if sports drinks are an effective yet realistic CHO supplement for children in competitive sports.

II. Procedures

In this study, you are expected to meet on three separate occasions for no more than two hours within a three-week period. The first session will include signing of consent forms, listening to instructions of the experiment, and practicing the test protocol. The second and third sessions will consist of the experimental trials.

Each experimental trial will consist of a warm-up and stretch period, a pre-test protocol, two 20 minute scrimmage periods (separated by a 5 minute rest period), and a post-test protocol.

The pre- test protocol will include:

- 2 soccer shots where ball speed will be recorded.
- 5 "Figure 8" dribbling patterns where completion time will be recorded.
- 20 passes against a wall where completion time will be recorded.
- 30 seconds of side-to-side hoping over a cone (repetitions will be recorded).

- 6 shuttles runs timed: Sprint forward 10-yards & return running backwards
- 40-yard sprint where completion times will be recorded.

The post-test will include the same exercise but in reverse order.

At the beginning of each trial, the subjects will consume 8oz of fluid. Between each change of activity, they will consume an additional 6oz of fluid. Total fluid consumption will be 32oz. For trial 1, one-half of the subjects will receive Gatorade™ while the other half will receive a placebo (Crystal Light™). For trial 2, the treatments will be reversed.

III. Risks and Efforts to Minimize Risks

You are asked to give maximal effort during the exercise. The level of effort during the experimental trials is comparable to that of a typical soccer practice or competitive game, so the risk of injury is no greater than that typically experienced by youth soccer players. Trained youth soccer coaches and athletic trainers will observe all sessions to identify players who appear to be at risk. Also, communication to emergency medical personnel will be available.

IV. Benefits of this Project

This study attempts to determine if consumption of sports drinks improve precise motor skills, speed, agility, and power during a soccer game. Because these beverages are so widely used among young athletes, it is imperative that their effects (or lack thereof) are known. Such information will greatly benefit young athletes who compete at intense levels for a prolonged period of time. In addition, it will provide parents with much needed information about the use of these beverages.

While confidentiality of results will be maintained, you can inquire about your own individual performance scores. The knowledge of your results may increase the awareness of your strengths as well as help you realize areas in which improvement is necessary.

V. Extent of Anonymity and Confidentiality

You will be identified by code and your results from the test protocol will be completely confidential. However, overall results of the study will be available to the public.

VI. Compensation

You will receive no compensation for participation in this project.

VII. Freedom to Withdraw

You may withdraw from this study at any time and do not have to answer any questions or respond to any experimental situations that you choose with no penalty. Your parents will be permitted to observe this project and may withdraw you at any time without penalty.

VIII. Approval of Research

This research project has been approved by the Institutional Review Board for Research Involving Human subjects at Virginia Polytechnic Institute and State University and the Department of Human Nutrition, Foods and Exercise.

IX. Subject's Responsibilities

You have the following responsibilities:

1. Complete a Health History questionnaire
2. Perform both trials to the best of your ability
3. Do not eat food 2 hours prior to each trial
4. Eat similar meals and snacks on both days of the trials

X. Subject's Permission

I have read and understand the Informed Assent and conditions of this project. I have had all of my questions answered. I hereby acknowledge the above and give my voluntary consent to participate in this project. I agree to abide by the subject responsibilities listed above.

______________________________	________________________
Signature	Date
______________________________	________________________
Witness	Date

Should I have any questions about this research or its conduct, I may contact:

Kim Stewart	Graduate Student
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Jay H. Williams, Ph.D.	Associate Professor
540-231-8298	Department of Human Nutrition, Foods and Exercise
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David Moore, D.V.M.	Chair

540-231-4991 Institutional Review Board
moored@vt.edu Virginia Tech

Medical and Health History Form

Name ______________________ Age: _________ Birth date______________

Parents/Guardians ____________________________ E-mail _________________

Address _____________________________________ Phone _________________

Person to contact in case of an emergency (other than parents) _______________

Relationship _________________________________ Phone _________________

Primary care physician _______________________ Phone _________________

Medical Insurance Carrier ____________________ SSN ___________________

Medical History: Please indicate any current or previous conditions or problems you have experienced or have been diagnosed by a physician to have had:

	YES	NO		YES	NO
Heart disease or any heart problems	____	____	Rheumatic Fever	____	____
Respiratory disease or breathing problems	____	____	Circulation problems	____	____
Kidney disease or problems	____	____	Urinary problems	____	____
Musculoskeletal problems (any muscle or	____	____	Diabetes		____
____					
skeletal limitations- i.e.. osteoporosis, or orthopedic injuries)			High Cholesterol	____	____
Fainting and Dizziness	____	____	Thyroid problems		____
____					
Allergies (e.g. Novocain)	____	____	Mental illness	____	____
Hypoglycemia (i.e. low blood sugar)	____	____	Epilepsy or Seizures	____	____

If you answered "yes" to any of the previous questions, please indicate the date and describe:
____
____
____
____

Please list any hospitalizations/operations/recent illnesses (type/date): _______________
____
____

Have you ever been diagnosed as having high blood pressure? ____ If yes, date:_______ Are you currently being treated for high blood pressure? _____ If yes, please explain:
____
____
____

Please list all medications (prescription and OTC) that you are currently taken or have taken in the past week: ____
____
____
______

For what reason(s) are you taking this medication? ________________________________
____
____
______

Control Habits: Do you engage in regular exercise? Yes ____ No ____
If 'yes", please list:

Activity	**Frequency (times per week)**	**Duration**
_____________	_____________________________	___________________________
_____________	_____________________________	___________________________
_____________	_____________________________	___________________________
_____________	_____________________________	___________________________

With exertion, do you ever faint, have shortness of breath, or have chest discomfort? ________

If "yes", please explain:____

____

____

______

Do you have any orthopedic limitations that may restrict your ability to perform soccer specific running and skills? ________ If "yes", please explain: _____________________

____

____

______

Family History: Has anyone in your family been diagnosed or treated for any of the following:

	Yes	No	Relationship	Age

Heart attack _______ _______ ______________ _________

Heart disease _______ _______ ______________ _________

High blood pressure _______ _______ ______________ _________

Stroke _______ _______ ______________ _________

Kidney disease _______ _______ ______________ _________

Diabetes _______ _______ ______________ _________

Please sign to indicate that the above information is correct:

______________________	________________________	_____________
Print Name	Signature	Date

Instructions for Participants

Both trials will be held in Gym 213 of Cassell Coliseum from 6:00-8:00 p.m. Enter through the 2nd floor doors along Spring Road. Please arrive a few minutes before 6:00.

Please remember to:

1. Record all food and drink intake on the appropriate form
   Follow normal eating habits on the day of the trial
   For Trial 2, please eat meals and snacks similar to those on the day of Trial 1

2. Refrain from eating two hours prior to the experiment (Do not eat after 4:00)

3. Bring a ball and a dark shirt to the experiment

4. Wear indoor/tennis shoes and a white shirt

5. Shin guards are highly recommended

Pizza will be provided after the experiment

Experimental Design

Day 1
Player's assent, Parent's consent
Medical History
Familiarization (scrimmage & one time through exercise protocol)

Day 2 (Trial 1)
Height
Weight
Fluid Intake (FI)- 8 ounces
Warm-up (do part of protocol) & Stretch
FI- 6 ounces
Pre-test exercise protocol
FI- 6 ounces
Scrimmage 2 X 20 minutes (with a 5 min half time- FI-6 ounces)
FI- 6 ounces
Post-test exercise protocol (in reverse order)

Day 3 (Trial 2)
Same as trial 2 (minus Ht and Wt)

Exercise Test Protocol:

Activity	Description
1. 2 Shots:	Shoot the ball and measure its speed
2. Dribbling:	5 “Figure 8” dribbling patterns timed- (cones 10-yds apart)
3. Passing:	Pass the ball against a wall from a distance of 5 yards Record time for 20 complete passes
4. Jumps:	Hop side to side over cones- Count repetitions in 30 seconds
5. Backwards:	Sprint forward 10-yds- return backwards- 6 reps-timed
6. 40 yd dash:	Sprint 40 yards

Page for Food Record

Participant's Age, Height, Weight and BMI

Subject	Age	Height (in)	Height (cm)	Weight (lb)	Weight (kg)	BMI (kg/m^2)
1	10	58.5	148.6	84	38.18	17.29
2	11	61.0	154.9	94	42.73	17.81
3	11	61.0	154.9	91	41.36	17.23
4	10	54.0	137.2	56	25.45	13.50
5	10	59.0	149.9	91	41.36	18.42
6	10	58.0	147.3	76	34.55	15.90
7	10	59.5	151.1	79	35.91	15.73
8	11	61.5	156	98	44.55	18.26
9	11	55.5	141	71	32.27	16.23
10	10	56.0	142.2	81	36.82	18.21
Mean ± SE =		**54.8 ± 0.81**	**148.3 ± 20.4**	**82.1 ± 3.69**	**37.32 ± 1.80**	**16.86 ± 0.49**

Appendix Table 1. Mean height, weight, and BMI measurements

APPENDIX B

Trial 1 and Trial 2 Data

#	Condition	Pre/Post (1/2)	Shot V	Dribble	Pass	Jumps	Shuttle	40 yd
1	G	1	39.5	46.24	19.39	64	43.02	6.54
1	G	2	42.5	46.12	20.80	62	42.90	6.26
1	P	1	42.5	45.44	17.00	62	45.94	6.62
1	P	2	39.0	42.97	20.84	60	45.68	6.56
2	G	1	40.0	44.22	15.61	53	45.55	6.18
2	G	2	38.0	47.55	17.00	49	46.27	6.29
2	P	1	39.5	44.69	15.09	56	45.83	5.97
2	P	2	34.5	46.74	18.12	57	42.30	6.28
3	G	1	38.5	44.46	14.09	48	43.33	6.18
3	G	2	40.0	44.06	15.18	56	45.30	6.22
3	P	1	38.5	43.56	15.89	54	44.10	6.13
3	P	2	39.5	50.76	14.17	47	45.86	5.84
4	G	1	35.5	44.28	19.62	57	39.44	6.23
4	G	2	36.0	44.34	19.84	57	40.30	6.03
4	P	1	35.0	44.15	19.18	58	42.92	6.19
4	P	2	34.0	46.67	16.92	51	41.94	6.42
5	G	1	35.5	46.16	18.85	58	44.19	6.68
5	G	2	33.5	45.27	19.87	55	45.81	6.79
5	P	1	33.5	53.00	17.45	55	46.72	6.60
5	P	2	29.0	50.92	15.70	53	45.68	6.65

6	G	1	38.0	46.16	21.00	60	45.48	5.91
6	G	2	38.0	45.30	22.88	55	43.24	6.38
6	P	1	38.0	46.43	25.10	59	41.60	6.28
6	P	2	35.5	47.96	19.79	61	42.83	6.73
7	G	1	40.5	44.67	12.90	60	39.51	6.32
7	G	2	39.5	47.14	17.38	61	41.43	6.31
7	P	1	40.5	45.30	15.84	69	43.27	6.26
7	P	2	38.0	45.10	14.09	58	43.46	6.27
8	G	1	37.0	57.38	22.91	37	45.30	6.76
8	G	2	38.5	54.79	24.16	41	46.74	6.75
8	P	1	38.5	56.18	30.61	41	44.78	6.51
8	P	2	37.5	56.34	22.49	35	47.32	6.41
9	G	1	34.5	49.25	19.97	59	44.67	6.50
9	G	2	34.5	56.90	15.85	45	45.41	6.46
9	P	1	38.0	49.77	20.28	57	42.94	5.82
9	P	2	32.0	48.80	20.62	55	46.53	6.47
10	G	1	44.0	45.01	22.79	73	46.02	5.98
10	G	2	43.5	41.60	17.21	52	41.48	6.24
10	P	1	44.0	43.93	14.74	60	42.20	5.82
10	P	2	45.0	43.71	16.36	41	45.45	6.18

Appendix Table 2. Raw data from Trial 1 and Trial 2

Calculated Mean Values

	Gatorade		Placebo	
	Pre	**Post**	**Pre**	**Post**
Shot Velocity	38.3 ± 0.9	38.4 ± 1.0	38.8 ± 1.0	36.4 ± 1.4
Dribbling	46.80 ± 1.27	47.31 ± 1.53	47.25 ± 1.36	47.99 ± 1.26
Passing	18.71 ± 1.09	19.02 ± 0.95	19.12 ± 1.61	17.91 ± 0.93
Jumping	55.1 ± 2.7	53.4 ± 2.4	55.8 ± 2.0	51.1 ± 2.9
Running backward	43.65 ± 0.76	43.89 ± 0.73	44.03 ± 0.55	44.71 ± 0.60
40 yard Sprint	6.33 ± 0.09	6.37 ± 0.08	6.22 ± 0.09	6.38 ± 0.08

Appendix Table 3. Mean values from the six exercise tests

Two Way Repeated Measures Analysis of Variance Calculations

Shot Velocity

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Subject	9	380.725	42.303		
Condition	1	5.625	5.625	3.716	0.086
Condition x Subject	9	13.625	1.514		
Time	1	13.225	13.225	4.756	0.057
Time x Subject	9	25.025	2.781		
Condition x Time	1	15.625	15.625	11.139	0.009
Residual	9	12.625	1.403		
Total	39	466.475	11.961		

Dribbling

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Subject	9	516.104	57.345		
Condition	1	3.318	3.318	0.449	0.52
Condition x Subject	9	66.535	7.393		

Time	1	4.07	4.07	0.974	0.349
Time x Subject	9	37.599	4.178		
Condition x Time	1	0.13	0.13	0.0265	0.874
Residual	9	44.188	4.91		
Total	39	671.944	17.229		

Passing

Source of Variation	DF	SS	MS	F	P
Subject	9	352.145	39.127		
Condition	1	1.232	1.232	0.238	0.637
Condition x Subject	9	46.603	5.178		
Time	1	2.043	2.043	0.524	0.488
Time x Subject	9	35.101	3.9		
Condition x Time	1	5.715	5.715	0.799	0.395
Residual	9	64.372	7.152		
Total	39	507.212	13.005		

Jumping

Source of Variation	DF	SS	MS	F	P
Subject	9	6858.13	762.015		
Condition	1	6.25	6.25	0.00896	0.927
Condition x Subject	9	6277.19	697.466		
Time	1	90.25	90.25	7.922	0.02
Time x Subject	9	102.528	11.392		
Condition x Time	1	20.25	20.25	0.968	0.351
Residual	9	188.25	20.917		
Total	39	1958.31	50.213		

Backward Running

Source of Variation	DF	SS	MS	F	P
Subject	9	87.987	9.776		
Condition	1	3.576	3.576	1.092	0.323
Condition x Subject	9	29.468	3.274		
Time	1	2.079	2.079	1.344	0.276

Time x Subject	9	13.928	1.548		
Condition x Time	1	0.48	0.48	0.155	0.703
Residual	9	27.93	3.103		
Total	39	165.448	4.242		

40-yard Sprint

Source of Variation	DF	SS	MS	F	P
Subject	9	1.583	0.176		
Condition	1	0.025	0.025	0.494	0.5
Condition x Subject	9	0.456	0.0506		
Time	1	0.106	0.106	2.43	0.153
Time x Subject	9	0.393	0.0437		
Condition x Time	1	0.0336	0.0336	1.623	0.235
Residual	9	0.187	0.0207		
Total	39	2.782	0.0713		

Appendix Table 4. ANOVA results for the six parameters

VITA

Kim Stewart was born on March 14, 1972 in Norfolk, Virginia. After graduating from Maury High School in 1990, she accepted a scholarship to play soccer at the University of Arkansas. After two years, Kim transferred to Mercer University where she continued to play soccer as well as basketball. She graduated with a B. A. in Mathematics in 1994. Because of the love she had for soccer, Kim decided to continue playing as well as becoming a coach. She joined the USL (a semi-professional women's league) and has played on a team ever since. As for coaching, she began her career as the Assistant Women's Soccer Coach at Furman University. After one season at Furman, Kim then accepted the Division I head coaching position at Southeastern Louisiana University and obtained her USSF "C" coaching license. She remained at SLU for three years before resigning in order to continue her playing career in Norway.

Upon returning to the states, she became a High School Mathematics teacher at Booker T. Washington in Norfolk, VA. After teaching, Kim decided to resume her coaching career as the Assistant Soccer Coach at Virginia Tech where she started her Masters degree in the Human Nutrition, Foods and Exercise Department in order to gain more knowledge of an athlete's needs. Once receiving her master's degree, Kim plans to continue her education in hopes of obtaining a Ph.D. so she can teach at the collegiate level.