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An Analysis of the Effects of the Carbohydrate Intake and Hydration on Feeling of Exertion Throughout a Marathon

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AN ANALYSIS OF THE EFFECTS OF THE CARBOHYDRATE INTAKE AND HYDRATION ON FEELING OF EXERTION THROUGHOUT A MARATHON

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ABSTRACT

The popularity of marathon running has grown exponentially since the 1970s (Noakes, 2003). This major gain in popularity has led to an increased interest in hydration and nutrition for marathon runners (Tucker et al 2009). The effects of dietary factors such as carbohydrates (CHO) and water on endurance has been extensively studied related to performance, but few studies have examined nutrition's effect on feelings of exertion. The current study aimed to determine how the in-race nutrition and hydration habits of marathon runners affect their feelings of exertion throughout a 26.2-mile race. Individuals running Grandma's Marathon in Duluth, MN on June 21st, 2014 were invited to complete an online survey, accessed via the Grandma's Marathon Facebook and Twitter pages, regarding their fluid and carbohydrate intake and feelings of perceived exertion throughout the race. Ratings of perceived exertion were recorded using the Borg's Rate of Perceived Exertion Scale. The survey responses of runners 18 years of age and older who finished the marathon within two standard deviations of the average time for their gender were included in data analysis. A correlation regression was performed in order to determine the relationship between carbohydrate and water intake and ratings of perceived exertion. It was concluded that there is no significant relationship between fluid and carbohydrate intake and ratings of perceived exertion throughout a marathon.

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CHAPTER 1

INTRODUCTION

Background

Marathon running has become increasingly popular since the 1970s. According to Noakes (2003), prior to the early 1970s, annual marathons were rare and the number of participants typically ranged from dozens to hundreds. In addition, these runners were elite, highly trained, and predominantly male athletes (Noakes, 2003). The dynamics of marathons have shifted significantly since the 1970s. This change in participation is illustrated through a comparison of the number of participants and the finishing time distribution between the New York City marathon in 1978 and the New York City marathon in 2001 (Noakes, 2003). In the year 1978, 8,588 runners participated in the marathon and 59.9% of these runners finished in four hours or less (Noakes, 2003). Conversely, 23,651 runners participated in the year 2001, with only 30.2% finishing under four hours (Noakes, 2003). Thus, while the number of marathon runners has increased significantly, the percent of runners finishing within four hours has decreased.

Marathon populations have expanded from solely elite runners, and are no longer considered only an athletic event but also a method of physical fitness participation (Noakes, 2003). Marathons are now full of both elite and recreational runners of all ages and athletic abilities (Noakes, 2003). Noakes (2003) notes that analysis of marathon demographics reveals a large percentage of runners who simply run for the satisfaction of finishing. The major gain in popularity has led to an increased interest in hydration and nutrition for marathon runners (Tucker et al 2009). Therefore, several studies have been conducted to determine how various methods of hydration and nutrition during a marathon effect runners' performance.

Attitudes regarding hydration while running have evolved significantly over the last several decades. According to Tucker et al (2009, p. 95), before the boom of the sports drink industry, preventing dehydration was not a major goal of runners. Tucker et al (2009, p. 96) shared a quote from the world record holding marathon runner, Jim Peters, that reflects the opinion of many runners before the establishment of the sports drink industry: “There is no need to take any solid food at all and every effort should be made to do without liquid, as the moment food or drink is taken…some discomfort will almost invariably be felt”. Although this approach to running may have been the standard at one point, researchers now understand the importance of hydration and share a very different message (Tucker et al, 2009, p. 97). Tucker et al (2009, p. 97) state, “To prevent possible catastrophic dehydration, the objective for runners should therefore be to start drinking early and then to drink often”. Therefore, it is clear that hydrating during an endurance race proves important. However, Tucker et al. (2009, p. 97) go on to discuss the risks of over hydration, such as hyponatremia. Because of this risk, runners must hydrate enough to prevent dehydration, but also be cautious not to overload their bodies with fluid (Tucker et al, 2009, p. 97).

The following studies have been conducted in order to determine how hydration and nutrition affect runners during a distance race. Research conducted by Montain et al (2006) offers information regarding fluid intake and incidence of dehydration and hyponatremia during a long distance run. Montain et al (2006) concluded that, while high levels of water intake resulted in fewer cases of dehydration, participants who consumed the highest level of water had the highest incidence of hyponatraemia. Thus, this study provides valuable information regarding the effects of fluid intake on distance runners.

Furthermore, the carbohydrate (CHO), defined as sources that shift from glucose and fatty acids to fatty acids and ketones (Westman et al, 2007), intake of marathon runners has been the focus of several studies. Carbohydrates have been analyzed in pre-race and during race situations to evaluate how they benefit runners' performance (Burke et al, 2005; Jeukendrop, 2004; Utter et al, 2002; Wilson et al, 2013). Athletes are often advised to maintain a high CHO diet, consume CHO before exercise, ensure adequate CHO intake during exercise, and replenish CHO stores as soon as possible after exercise (Jeukendrup, 2004). Research on the effects of CHO intake before and during exercise has accumulated since the beginning of the 20th Century (Jeukendrup, 2004). Since CHO has become an emphasis in exercise, many different sports products such as gels, goo, and gummies have been produced to offer runners a high concentration of CHO within a small volume during a race. However, multiple studies have shown that in race nutrition does not significantly improve performance time in endurance running (Wilson et al, 2013; Burke et al, 2005; Utter et al, 2002).

In a study conducted by Burke et al (2005), runners that habitually utilized water and CHO during races stated that they would continue to consume CHO, in the form of gels, in the future even though use of these gels did not improve their marathon performance. The participants claimed that the use of CHO caused a major positive change in their running habits (Burke et al, 2005). Burke et al (2005) never further explained this "major change", but it may be interpreted that the participants' habitual CHO intake during races improved their feelings of exertion during the race. Thus, more research must be conducted with the goal revealing the relationship between carbohydrate intake and feelings of exertion in order to complement the information provided by studies that compare carbohydrate intake and performance.

Problem Statement

A lack of information exists regarding the effect of nutrition and hydration on participants' perceived levels of exertion throughout a marathon. Many studies have focused on the effect of nutrition and hydration on athletes' performance (Burke et al, 2005; Jeukendrop, 2004; Wilson et al, 2013), but few have focused their efforts towards the effect of nutrition on the athletes' perception of exertion. Thus, further research must be conducted in order to determine how nutrition and hydration strategies during a marathon affect how runners feel throughout the race.

Purpose

The intent of this study was to gain insight into how the hydration and nutrition habits of marathon runners affect their feelings of exertion throughout a 26.2-mile race. While many researchers have investigated the quantitative aspects of marathon nutrition, questioning the qualitative effects of nutrition revealed a major void in understanding. Many studies focus on the measureable effects of nutrition and hydration, such as heart rate, electrolyte levels, and finishing time; therefore, the understanding of the qualitative effects of nutrition during an endurance race proves satisfactory. However, there was little awareness about how varying hydration and nutrition strategies affect the perceived exertion of runners during a marathon. The goal of this study was to acquire information that will help to shrink this gap in information.

Significance of Study

This study analyzed the relationship between runners' feelings of exertion and their hydration and carbohydrate intake throughout a 26.2-mile race, in order to investigate the qualitative effects of nutrition. Knowledge of runners' exertion levels throughout a marathon provides further information on the qualitative risks and benefits of common hydration and nutrition strategies during endurance running. Through exploration of the issue, this study reveals whether the amount and rate of carbohydrate intake provides perceived exertional benefits. In addition, this study also provides information regarding the effects of water intake on feelings of exertion throughout a marathon. The study also investigated the possible harm carbohydrate intake and hydration routines have on runners' feelings of exertion by analyzing side effects, such as hyponatremia and GI complications. Runners of all future marathons benefit from such information, as they can incorporate data from this study in their hydration and carbohydrate regimen to improve their feelings of exertion and avoid associated complications. Results from this study lessen the gap of qualitative research regarding the relationship between nutrition and hydration strategies and the feelings of exertion that runners experience during a marathon.

Research Questions

Using methods discussed in chapter three, this study sought to answer the following research questions:

1. What, if any, effect does marathon runners' amount and rate of water intake have on their exertion level throughout the duration of the race?
2. What, if any, effect does marathon runners' amount and rate of carbohydrate intake have on their exertion level throughout the duration of the race?

CHAPTER 2

LITERATURE REVIEW

Introduction

Literature has shown various results on hydration and nutrition routines of athletes in relation to performance. The research includes hydration in relation to performance, side effects of deficit or over hydration, carbohydrates in relation to performance, side effects of carbohydrate intake, and exertion scales used in previous research. The following review of literature summarizes research studies pertaining to these topics.

Hydration Effect on Performance

According to Burke, Millet, and Tarnopolsky (2007), large community participation events often supply runners with water and sports drinks throughout the race. Brown, Chiampas, Jaworski, and Passe (2011) conducted a study in order to gather information regarding the types of fluid runners drank during a marathon. Brown et al. (2011) surveyed 419 runners at a Midwest marathon. Of the 419 survey participants, 71.0% reported drinking both water and sports drinks during the race, 17.7% reported drinking only water, and 11.0% reported drinking only sports drinks (Brown et al., 2011). In addition, Williams, Tzortziou-Brown, Malliaras, Perry, and Kipps (2012) report that greater than 60% of the 217 runners surveyed at the 2010 London Marathon also reported drinking both water and sports drinks during the race. Therefore, based on the data collected by Brown et al. (2011) and Williams et al. (2012), water and sports drinks both prove popular methods of hydration for marathon runners.

While it remains unclear which hydration strategy has the most positive impact on runners' feelings of exertion, research has been conducted to determine how race hydration affects performance (Burke et al., 2007). For example, Stellingwerff (2013) analyzed the marathon performance of Haile Gebrselassie, an elite marathon runner, in order to determine how his fluid and carbohydrate intake affected his performance. Gebrselassie consumed only water in the 2002 London Marathon and finished in a time of 2:06:35 (Stellingweff, 2013). Conversely, in the 2008 Berlin Marathon, Gebrselassie consumed about 60-70 g/h of carbohydrates in addition to water (Stellingweff, 2013). According to Stellingweff (2013), Gebrselassie finished the 2008 Berlin Marathon in 2:03:59, a 2% improvement from the 2002 London Marathon. While many factors may have contributed to Gebrselassie's improvement in finishing time, the addition of carbohydrates to his race intake likely played a role in his time improvement (Stellingweff, 2013). Thus, hydration plays an important role in marathon performance, but carbohydrate intake may improve marathon performance (Stellingweff, 2013).

Furthermore, a study conducted by Beis, Wright-Whyte, Fudge, Noakes, and Pitsiladis (2012), analyzed the hydration habits and performance of ten elite marathon runners in 13 major city marathons. These runners drank an average of 0.55 ± 0.34 L/h and had an average finishing time of 02:06:31 $\pm$ 00:01:08 (Beis et al., 2012). According to Beis et al. (2012), there was no significant relationship between total fluid intake and running speed. Thus, based on the results of this study, it does not appear that hydration has a significant impact on performance; however, this study only analyzed a specific group of runners, so it would be useful to investigate a more diverse collection of marathon runners in order to test this hypothesis further (Beis et al., 2012).

Additionally, Beis et al. state that the participants in their study drink ad libitum, or to thirst, during their training and races. Tucker and Dugas (2009) support the theory of drinking to thirst in their book *The Runner's Body.* Tucker and Dugas (2009) state that performance will be optimized if runners drink according to thirst. According to Tucker and Dugas (2009), the thirst mechanism is incredibly sensitive; thus, obeying thirst proves the most effective way to ensure fluid balance throughout an endurance race.

Finally, Hew, Chorley, Cianca, and Divine (2003) established a relationship between over-hydration and performance in their study conducted during the 2000 Houston Marathon. This study specifically analyzed the incidence of hyponatremia in participants of the 2000 Houston Marathon, and it will be discussed in further detail in the following section of this chapter (Hew et al., 2003). However, in addition to collecting data regarding hyponatremia, Hew et al. (2003) also examined the total fluid intake and finishing times of participants. Hew et al. (2003) concluded that the runner who drank the highest amounts of total fluid, both water and electrolyte drinks, had the slowest finishing times. Therefore, consuming too much fluid may have a negative impact on marathon performance.

<u>Risks of Deficient Hydration or Excessive Hydration– Dehydration and Hyponatremia</u>

Williams, Brown, Malliaras, Perry, and Kipps (2012) define exercise-associated hyponatremia as, “serum sodium concentration of less that 135 mmol/L during, or up to 24 hours after, prolonged physical activity.” Symptoms of hyponatremia include nausea, vomiting, muscle cramps, lethargy, seizures, and altered mental status (Tucker & Dugas, 2009). The primary cause of exercise-associated hyponatremia is excessive fluid intake (Williams et al., 2012). According to Tucker and Dugas (2009), since 1986, many runners have been hospitalized due to exercise-associated hyponatremia following events. The following studies have been conducted to investigate the knowledge runners have regarding the risk of hyponatremia and the effect of hydration on the incidence of hyponatremia. Researchers at the 2010 London Marathon obtained information from runners regarding their hydration strategies and knowledge regarding hyponatremia (Williams et al., 2012). A random group of 217 London Marathon runners participated in a survey that asked questions regarding their demographic information, drinking strategies, sources of information about fluid intake, and understanding of proper fluid intake and risk of hyponatremia (Williams et al., 2012). According to Williams et al. (2012), 93.1% of the participants had a plan regarding fluid intake during the race; however, only 35.5% of runners in this study had a basic understanding of the causes and effects of hyponatremia and 12% of participants planned to drink a volume of fluids large enough to put them at higher risk for exercise-associated hyponatremia. Therefore, while many runners have a hydration strategy in place, some may be unaware of the risks associated with inappropriate fluid intake.

Moreover, Hew et al. (2003) conducted a study with the goal of determining incidence and risk factors of hyponatremia in marathon runners. Hew et al. (2003) collected data from 73 patients treated in the major medical facility at the 2000 Houston Marathon. According to Hew et al. (2003), 55 of these patients were unable to tolerate oral fluids and received IV fluids. The serum electrolyte levels of these 55 patients were checked immediately and the incidence of hyponatremia was noted: 34 runners had normal serum sodium levels, eight had serum sodium levels between 130-135mmol/L (mild hyponatremia), eleven had serum sodium levels between 120-129mmol/L (moderate hyponatremia), and two had serum sodium levels below 120mmol/L (critical hyponatremia) (Hew et al., 2003). Furthermore, a medical questionnaire was sent to 68 of the 73 runners cared for in the major medical facility and was returned by 17 of the runners classified as hyponatremic and 22 of the runners classified as non-hyponatremic (Hew et al., 2003). From analysis of these questionnaires, Hew et al. (2003) established relationships between fluid intake, finishing times, and incidence of hyponatremia. There was a significant inverse relationship between finishing time and serum sodium levels; runners with the lowest serum sodium levels had the slowest finishing times (Hew et al., 2003). In addition, the hyponatremic runners drank significantly more water and electrolyte/carbohydrate drinks than non-hyponatremic runners (Hew et al., 2003). Females who presented to the major medical facility and were classified as hyponatremic drank an average of 57 cups of fluid throughout the race, and males in this category drank an average of 49 cups of fluid (Hew et al., 2003). Conversely, females who reported to the major medical facility and were classified as non-hyponatremic drank an average of 31 cups of fluid, and males in this category drank an average of 28 cups of fluid (Hew et al., 2003). Therefore, the study conducted by Hew et al. (2003) and the 2000 Houston Marathon revealed a significant relationship between increased fluid intake, incidence of hyponatremia, and slower finishing time.

Furthermore, research conducted by Montain, Cheuvront, and Sawka (2006) offers information regarding fluid intake and incidence of both hyponatremia and dehydration during a long distance run. Participants in this study participated in a controlled long distance run while drinking 400mL, 600mL, or 800mL of water or sports drink every hour (Montain et al., 2006). Researchers measured the body mass loss and plasma sodium concentration of their participants throughout this run in order to evaluate how these various amounts and types of fluid influenced dehydration and hyponatraemia in the runners (Montain et al., 2006). Montain et al. concluded that, while high levels of water intake resulted in fewer cases of dehydration, participants who consumed the highest level of water had the highest incidence of hyponatremia. In addition, Montain et al. found that consuming 800mL of a sport drink, containing 20mEq/l of sodium, prevented the development of hyponatraemia in the runners.

Thus, Mountain et al. provide useful information regarding the relationship between fluid intake and incidence of hyponatremia in distance runners.

Carbohydrate Effect on Performance

After years of research, it is generally accepted that carbohydrate (CHO) during exercise can improve exercise capacity and performance during prolonged exercise (<2 hour duration) (Jeukendrup, 2004). Krogh and Lindhard (1920) were among the first to recognize the impact of CHO during exercise. They found that subjects reported exercise (stationary biking) as less strenuous if they had consumed a CHO-rich diet compared to a high fat diet (Krogh & Lindhard, 1920). This was also shown by higher respiratory exchange ratios during exercise with high-CHO diets (Krogh & Lindhard, 1920). Since that time, research on CHO during exercise and performance has vastly expanded.

Dr. Asker Jeukendrup developed a review of nearly 100 years of CHO research relating to performance with intent to analyze CHO during exercise, the minimal amount of CHO required, different forms of CHO, mechanisms by which CHO feeding improves performance, and metabolism of CHO (2004). This review focuses on studies pertaining to the effects of CHO on endurance capacity and performance when ingested during exercise. Jeukendrup (2004) illustrates that previous research is divided on the benefits of CHO feeding during exercise on endurance capacity. While Fielding et al. (1985), Neufer et al. (1987), Mitchell et al. (1988), and Hargraves, Costill, Fink, and Nishibata (1984) reported beneficial endurance effects of CHO intake during exercise, Bjorkman, Sahlin, Hagenfeldt, and Wahren (1984), Murray, Seifert, Eddy, Paul, and Halaby (1989), and Sasaki, Maeda, Usui, and Ishiko (1987) did not find CHO to benefit endurance and performance during exercise (Jeukendrup, 2004). Jeukendrup (2004) notes the difficulty of comparing performance and endurance results with CHO as performance evaluation varies across all studies. After taking different methods into account, he reports that compilation of results of CHO impact on endurance and performance is convincingly in favor of the ones that show ergogenic effects of CHO during exercise (Jeukendrup, 2004).

When analyzing studies on minimal amounts of CHO required during exercise to benefit performance, Jeukendrup (2004) concluded overall that performance benefits were found at 16 g/hour, but no further improvement has been observed with larger amounts. Further, an analysis of all studies indicated that a single CHO ingested during exercise will be oxidized at rates up to 1g/min. Combinations of CHO that use different intestinal transporters for absorption such as glucose and fructose produce even higher oxidation rates (Jeukendrup, 2004).

While Jeukendrup (2004) provides a well-rounded review of CHO intake during exercise, recent research has been focused specifically on CHO intake and performance in marathon runners. Utter et al. (2002) conducted a double-blind study that divided a group of 102 marathon runners into two random groups; one group was given a placebo drink and the other was given a carbohydrate drink. Each group was instructed to drink 650mL of their drink 30 minutes prior to beginning the marathon and 1,000mL every hour during the race. During the race, the heart rate of each runner was recorded every 3.2km. In addition, the post-race levels of plasma glucose, lactate, and insulin were measured in each runner. Utter et al. (2002) reported the heart rate of CHO runners was significantly higher than the rates of those in the placebo group and the plasma glucose, lactate, and insulin levels were also significantly higher in the carbohydrate group. Also, Utter et al. (2002) noted that the finishing time did not vary significantly between the two groups.

A study by Burke, Wood, Pyne, Telford, and Saunders (2005) analyzed the effect of CHO on 18 well trained (actual or predicted half marathon of 75 minutes or less) male runners' performance in half marathons. Runners consumed either a placebo flavored drink or water and CHO gel supplement providing 1.1 ± 0.2 g/kg body mass carbohydrate. Participants ran two half marathons within 3 weeks of each other and performance times were averaged for analysis. Those who consumed CHO had better performance (0.3%, 14 seconds) than the placebo group. However, three participants that consumed the CHO gel supplement complained of associated GI problems, which ultimately resulted in deficient in performance (2.4%, 105 seconds). It was also found that gel runners had a slower time through the feeding zone compared to the placebo group, which resulted in an average loss in 2 seconds. Burke et al. (2005) concluded that there was a lack of evidence or worthwhile enhancement on half marathon performance since finishing times were not significantly different, and CHO seemed to cause additional GI complications.

Wilson, Ingraham, Lundstrom, and Rhodes (2013) had similar results to Burke et al. (2005). Wilson et al. (2005) analyzed dietary tendencies of students at the University of Minnesota that participated in Physical Education 1262 Marathon Training. Most of the students were novice marathon runners, with a few that had participated in marathons before. They examined the association between prerace and in-race marathon nutrition and performance by recording nutrition 3 days prior, morning of, and during the marathon (Wilson et al., 2013). The only nutrition predictor that had a significant relation to marathon time was day before and morning of carbohydrate intake and in race nutrition intake did not significantly predict performance time (Wilson et al., 2013). Therefore, while Jeukendrup's review (2004) reports benefits of CHO during exercise on endurance and performance, the recent research on CHO intake during marathons does not prove to have significant performance benefits (Utter et al., 2002; Burke et al., 2005; Wilson et al., 2013).

Carbohydrate Side Effects – Gastrointestinal Complications

As previously stated in the study by Burke et al. (2005), gastrointestinal (GI) complications are not an uncommon problem associated with carbohydrate intake. In the study by Burke et al. (2005), these GI side effects proved to have a detrimental on runner's performance times with an average of 2.4% decrease (105 seconds). As there is little information about the actual nutrition and fluid intake habits and GI symptoms of athletes during endurance events, a study by Pfeiffer et al. (2012) aimed to quantify and characterize carbohydrate, nutrient, and fluid intakes during endurance competitions and investigate associations with GI symptoms. They analyzed 221 endurance athletes from various areas such as triathlons, marathons, and cyclists. Athletes were given a post-race survey to quantify nutrient intake and analyze GI symptoms (reflux/ heartburn, belching, bloating, stomach cramps/pain, nausea, vomiting, intestinal/lower abdominal cramps, flatulence, urge to defecate, side ache/stitch, loose stool, diarrhea, intestinal bleeding) as well as systemic symptoms on a scale of 0-9 in each competition (Pfeiffer et al., 2012). GI symptoms rated greater than 4 were considered serious. Carbohydrate intake rates showed to vary greatly between both events and individuals (6-136 g/hour) (Pfeiffer et al., 2012). Ironman individuals consumed the most CHO on average (65 ± 25 g/hour) and marathon individuals consumed the least amount of CHO in race on average (35 ± 26 g/hour) (Pfeiffer et al., 2012). Ironman participants had approximately 31% of individuals that complained of GI symptoms, while marathon participants only had approximately 4% of individuals with GI symptoms (Pfeiffer et al., 2012). In all data sets, scores for GI symptoms correlated with a history of GI distress in the past (Pfeiffer et al., 2012). High

CHO intake during exercise was related not only to increased scores for nausea and flatulence but also to better performance during Ironman races, specifically in Hawaii and Germany (Pfeiffer et al,. 2012).

Borg's Ratings of Perceived Exertion Scale

In his article, *Psychophysical Bases of Perceived Exertion* Gunnar A.V. Borg (1982) states, "In my opinion perceived exertion is the single best indicator of the degree of physical strain." It was this belief that prompted him to create a scale that could be used to measure the perceived exertion of individuals during physical activity (Borg, 1982). Borg created a 15-point scale ranging in values from six to twenty, with six representing the least exertion and twenty representing the most exertion (Borg, 1982). In addition, these number values correspond with descriptions of exertion ranging from very, very light to very, very hard (Borg, 1982). According to Borg (1982), "[Rating of Perceived Exertion] scale is the best for most simple applied studies of perceived exertion, for exercise testing, and for predictions and prescriptions of exercise intensities in sports and medical rehabilitation." Thus, Borg's Scale is applicable to this study, as it provides a means of quantifying the feelings of exertion felt by runners throughout a marathon.

Borg's Ratings of Perceived Exertion Scale was used in a study conducted by Duckworth, Backhouse, and Stevenson (2013). In their study, Duckworth et al. (2013) wished to determine the effects of carbohydrate intake on female runners. Each participant took part in three trials in which they drank a carbohydrate and glucose drink, carbohydrate and galactose drink, or a placebo drink (Duckworth et al., 2013). According to Duckworth et al. (2013), participants consumed designated amounts of these drinks ten minutes prior to a 60-minute treadmill run and every fifteen minutes throughout the run. Runners were asked to rate their level of exertion using Borg's scale every fifteen minutes throughout the run (Duckworth et al., 2013). The results of this study did not show a significant difference in ratings of perceived exertion between participants who drank a carbohydrate and glucose drink, participants who drank a carbohydrate and galactose drink, and participants who drank a placebo drink (Duckworth et al., 2013). This study demonstrates how Borg's Ratings of Perceived Exertion Scale can be used to determine the effectiveness of various hydration and nutrition strategies utilized by runners.

Summary

The purpose of this literature review is to outline the major findings of hydration and carbohydrate supplementation routines over the last nearly 100 years. Studies were done to determine the benefits of hydration on performance, benefits of carbohydrates on performance, ideal rate of hydration for optimal performance, ideal rate of carbohydrate supplementation for optimal performance, and to examine side effects of both deficient or excessive consumption of both hydration and carbohydrates. By examining previous research, this current study is able to adjust the research questions to meet the needs of marathon athletes and address the gaps in the literature. While the above studies provide ample research of runners' nutrition in relation to performance, there is a gap of information relating runners' in race nutrition to their feelings of exertion. Such information would be valuable to marathon runners and other endurance athletes in order to maximize their experience and performance during races. The current study aims to close this gap of information formed from previous research and will reflect the method designs of previous studies. Review of previous research aids the current study in forming predictions for the results.

CHAPTER 3

METHODOLOGY

Introduction

The purpose of this study was to examine the relationship between nutrition and hydration strategies and ratings of perceived exertion of marathon runners throughout a 26.2-mile race. This study aimed to answer the following two questions regarding hydration and nutrition and ratings of perceived exertion.

1. What, if any, effect does marathon runners' amount and rate of water intake have on their exertion level throughout the duration of the race?
2. What, if any, effect does marathon runners' amount and rate of carbohydrate intake have on their exertion level throughout the duration of the race?

This chapter describes the following aspects of this study: sample population, participant enrollment, method of data collection, study design, validity and reliability, procedures, statistical analysis, and limitations.

Sample Population

Participation in this study was limited to individuals running the 2014 Grandma's Marathon on June 21st 2014. Both male and female marathon finishers were eligible to participate in this survey. In addition, runners aged 18 and older were included in this study.

Participant Enrollment

In order to reach a large number of runners in a convenient manner, the subjects in this study were contacted through the Grandma's Marathon Facebook and Twitter pages. In 2013, 5,620 individuals finished Grandma's Marathon, and the number of 2014 finishers is estimated to be similar to this number (2013 Grandma's Marathon, 2013). While not all of these runners access Facebook and Twitter, distributing the survey via social media ensured the survey reached a large number of participants. Therefore, a considerable amount of data was gathered.

Methods of Collection

Data for this study was collected using a survey method. The web-based survey created via SurveyMonkey was first distributed to a review panel composed of experienced marathon runners of various ages. These individuals were asked to review the survey and provide feedback on its readability and clarity. Upon approval from this review panel, a link to the online survey was distributed to Grandma's Marathon runners via the Grandma's Marathon Facebook and Twitter pages.

The first section of this survey included demographic questions. This section aimed to gain information regarding runners' age and gender, amount of training, and self-reported 2014 Grandma's Marathon finishing time. The second portion of the survey was composed of original questions regarding carbohydrate and water consumption throughout the marathon. Participants were asked to select the carbohydrate product(s) they consumed throughout the race from a list of commonly used nutrition products used by marathon runners. They also had the option to record any additional products they used that are not included in the list. Once product(s) were selected, participants were prompted to document how much product they consumed and at approximately what mile marker(s) they consumed the product. Next, participants were asked to repeat this documentation of intake in regards to water and Powerade Ion4 consumption throughout the race. Again, the participants had the option to list and document intake of any additional hydration products used throughout the race.

Furthermore, the third section of the survey was created using Borg's Rate of Perceived Exertion (RPE) scale. According to Utter, Kang, and Robertson (2010), the RPE scale provides a means of measuring feelings of effort, discomfort, strain, and fatigue. Therefore, this scale allowed runners to communicate their feelings of exertion throughout the marathon. The RPE scale includes values from six to twenty, with six representing no exertion and twenty representing maximal exertion (Utter et al., 2010). This scale was included, along with a description of its values, in the survey distributed to Grandma's Marathon runners. Survey participants were asked to select the number on the RPE scale that best describes their feelings of exertion at each of the fifteen water stations throughout the course.

Study Design

This was a qualitative, retrospective study that focused on the runners of the 2014 Grandma's Marathon. To study the correlation between in race nutrition and hydration intake and perceived exertion, carbohydrate and water intake were the independent variable and perceived exertion was the dependent variable. Race participants were provided with access to a web-based survey prior to the 26.2-mile race via hyperlink posted on the Grandma's Marathon Facebook and Twitter pages. They were encouraged to familiarize themselves with the survey before the marathon. After the race, study participants completed the survey and submited it online. The survey contained basic questions regarding demographics, amount of training, and finishing time. It also included questions regarding carbohydrate consumption, water consumption, and feelings of exertion throughout the race.

Validity and Reliability

Borg's Rate of Perceived Exertion scale has been used in other research regarding the relationship between nutrient intake and feelings of perceived exertion during distance running (Utter et al., 2002; Duckworth, Backhouse, & Stevenson, 2013). Thus, the validity of Borg's Rate of Perceived Exertion scale was established by past studies. In addition, the questions included in this survey pertain to marathon running and nutrient intake. Therefore, these questions prove valid for the target population. In addition, the survey review panel reviewed the survey prior to its distribution to study participants in order to further establish its validity. On the other hand, because this is the first application of this survey as a whole, it proved difficult to determine its reliability. The participants will complete the survey through self-reporting, so the reliability of the information they provide proved unclear.

Procedure

The support services coordinator for Grandma's Marathon was provided with a link to the online survey in the summer of 2014. The link to the online survey along with brief explanation of the study was posted on the Grandma's Marathon Facebook and Twitter pages periodically throughout the weeks leading up to, and for one week following the race on June 21st, 2014. Marathon participants had access to the survey before and after the race via the link provided on Facebook and Twitter. Following completion of the race, runners responded to the survey and submitted it online. Online surveys were accepted until July 1st, 2014. Participants that do not finish the marathon and participants that do not finish within two standard deviations of the average finishing time for their gender as told by their self-reported finishing times were excluded from the study. In addition, participants who did not complete at least three months of training before the race were also excluded. Survey responses from runners that do not meet the finishing time and training requirements were not included in the data analysis.

Statistical Methods

Information received from the surveys was sorted, and the data provided by non-finishers or runners who finished outside of two standard deviations of the average finishing time for their gender was excluded from data analysis. Data reduction was done on the types of carbohydrate products consumed by participants in order to quantify the amount of carbohydrates ingested by each participant. Data reduction was also done to quantify water intake for each participant. These quantified amounts of carbohydrate and fluid intake were assigned scores for data analysis. The data was entered into SPSS and a correlation regression analysis comparing carbohydrate and water intake to feelings of perceived exertion was completed in order to determine the relationship between these variables.

Limitations

It was predicted that this study may be limited by a low response rate. Participants were required to complete the survey post-race completion; this may have decreased the response rate, as event activities may no longer be a priority for the runners. In addition, after the race was finished, the runners may have had difficulty remembering details about their carbohydrate and water intake and feelings of exertion throughout the race. The methods of this study attempted to overcome this limitation by encouraging participants to familiarize themselves with the survey prior to the marathon. This helped to ensure that participants knew to keep track of their intake during the race.

Lack of personal contact between the research conductors and the study participants proved another limitation of this study. By simply accessing the survey online, study participants may have misunderstood aspects of the survey. This lack of understanding may have had an effect on the reliability of the results. Additionally, participants may have been more inclined to falsify the data on their surveys than they would have been if they had personal contact with the researchers. Since participants self-reported their intake and feelings of exertion, it was difficult to establish the reliability of this information.

Finally, the current study did not inquire about participants' night-before and morning-of hydration and nutrition intake. From the literature review, it has been shown that these aspects of CHO intake have significant effect on performance. Therefore, it is possible that these nutritional aspects may have affected participants' feelings of exertion throughout the race. This limitation offers areas for future research to expand and analyze the effects of night-before and/or morning-of CHO and water intake on runner's feelings of exertion throughout a 26.2-mile marathon.

CHAPTER 4

RESULTS

This study resulted with 200 participants that answered the web-based survey. Participant surveys were eliminated from the data analysis if they did not complete the survey, did not meet the age inclusion criteria of 18 years and older, gave answers that were illegible or unclear, or stated a RPE of 6 or 20 at any mile marker as 6 represents no exertion and 20 represents maximal exertion (Borg, 1982). Participants were also eliminated from the data analysis if they finished outside of two standard deviations of the average finishing times for their gender. The average finishing time for women was 4:28:00 with a standard deviation of 49:48 (2014 Grandma's Marathon, 2014). The average finishing time for men was 4:04:06 with a standard deviation of 49:10 (2014 Grandma's Marathon, 2014). Therefore women who finished under 2:48:24 or over 6:13:06 and men who finished under 2:25:46 or over 5:42:26 were not included in the data analysis. Elimination criteria is outlined in Table 1. After eliminating participants that did not meet the above criteria, there were 113 surveys eligible for data analysis. Of the 113 eligible surveys, 41 surveys were male participants and 72 surveys were female participants. Therefore, 36.28% of the surveys included in data analysis represent men and 63.72% represent women runners. The average age of male participants was 40.83 years old, and the average age of female participants was 33.87 years old.

Exclusion Criteria
Age < 18
Women who finished earlier than 2:50:04
Women who finished after 6:06:96
Men who finished earlier than 2:25:86
Men who finished after 5:42:26
RPE value of 6 or 20 reported at any point throughout the race
Incomplete surveys
Illegible or unclear survey responses

Table 1. Summary of participant exclusion criteria from final data analysis

Data reduction was done to calculate the amount of CHO and fluid participants consumed throughout the race. Amount of fluid intake was calculated in ounces. Unless participants recorded their fluid intake in ounces, "one cup" of fluid was interpreted as 4 ounces for this study because volunteers only fill cups half-full at hydration stations. Amount of carbohydrate intake per participant was calculated in grams. The amount of carbohydrate per product was found on product websites. Clif Shot Blok is 24 grams/3 pieces with 6 pieces per package (Clif Bar - Athlete Series – Bloks, 2014). Clif Energy Gel is 22 grams per packet (Clif Bar - Athlete Series - Energy Gel, 2014). GU Energy Gel is 22 grams per packet (GU Energy Gel | GU Energy Labs, 2014). Jelly Belly Sports Beans were 25 grams per packet (Jelly Belly Sport Beans®, 2014). Participants were also given an option to select 'Other' when asked what type of CHO products they used throughout the race. Data reduction was also done on these products to calculate the amount of CHO intake of participants. Other CHO products included Hammer Gel 23 grams per packet (Hammer Gel, 2014), Accel gel 20 grams per packet (Pacific Health, 2014), GU Chomps 23 grams per package (GU Energy Chews | GU Energy Labs, 2014), Powerbar gel 27 grams per packet (PowerBar.Com | PowerGel®, 2014), Huma Chia Gel 22 grams per packet (Huma Gel, 2015), Advocare gel 21 grams per packet (Advocare, 2015), Honey Stinger gel 29 grams per packet (Honey Stinger, 2013), Honey Stinger chews 39 grams per 10 piece package (Honey Stinger, 2013), banana 30 grams (Chiquita Brands, 2015), orange 11 grams(Sunkist Growers. Inc,, 2015), PocketFuel 6 grams (PocketFuel, 2014), Larabar 30 grams (LÄRABAR, 2015), and Clif bar at 45 grams (Clif Bar, 2014). Powerade Ion4 was offered at water stations and has 21 grams of CHO per 12 oz (Powerade, 2015). These products and associated carbohydrate quantities are outlined below in Table 2.

Products Consumed	**Carbohydrates per package**
Clif Shot Blok	24 gr/3 pieces
Clif Energy Gel	22 gr
GU Energy Gel	22 gr
Jelly Belly Sports Beans	25 gr
Hammer Gel	23 gr
Accel Gel	20 gr
GU Chomps	23 gr
Powerbar Gel	27 gr
Huma Chia Gel	22 gr
Advocare Gel	21 gr
Honey Stinger Gel	29 gr
Honey Stinger Chews	39 gr
Banana	30 gr
Orange	11 gr
PocketFuel	6 gr
Larabar	30 gr
Clif Bar	45 gr
Powerade Ion4	21 gr/12 oz

Table 2. Summary of reported carbohydrate products consumed by Grandma’s Marathon 2014 participants with the associated carbohydrate amounts per package

The average amount of fluid intake throughout the race among the 113 included participants was 59.68 ounces with a standard deviation of 31.18 ounces. The average amount of carbohydrate intake throughout the race among the 113 included participants was 115.78 grams with a standard deviation of 49.34 grams CHO.

Data analysis included a multiple correlation regression performed using SPSS and Excel comparing carbohydrate intake to feelings of perceived exertion, and fluid intake to feelings of perceived exertion to answer the research questions. The amount of fluid/CHO intake was the independent variable, while the rating of perceived exertion was the dependent variable. Table 3 and table 4 demonstrate the results of fluid intake versus RPE. Table 5 and table 6 demonstrate the results of carbohydrate intake versus RPE.

Source	DF	Sum of Squares	Mean Square
Regression	15	6547.50321	436.50021
Residual	97	102337.95697	1055.03048
F-ratio			0.41373
Significance level			P=0.9720

Table 3. Analysis of Variants comparing fluid intake and RPE by mileage

There is no significant difference found when comparing the amount of carbohydrate intake throughout the 2014 Grandma's Marathon 26.2 to runners' ratings of perceived exertion, as demonstrated by the p-value of 0.9720 from the ANOVA in Table 3.

Sample size	113
Coefficient of determination R^2	0.06013
R^2-adjusted	-0.08521
Multiple correlation coefficient	0.2452
Residual standard deviation	32.4812

Table 4. Least squares multiple regression comparing fluid intake and RPE by mileage

There is an R-squared value of -0.08521 when looking at the correlation regression of fluid intake and RPE by mileage, therefore, indicating no relationship between the independent and dependent variables.

Source	DF	Sum of Squares	Mean Square
Regression	14	26429.01862	1887.78704
Residual	98	246281.77673	2513.07935
F-ratio			0.75118
Significance level			P=0.7180

Table 5. Analysis of Variants comparing carbohydrate intake and RPE by mileage

There is no significant difference found when comparing the amount of carbohydrate intake throughout the 2014 Grandma's Marathon 26.2 to runners' ratings of perceived exertion, as demonstrated by the p-value of 0.8155 in Table 5.

Sample size	113
Coefficient of determination R^2	0.09691
R^2-adjusted	-0.03210
Multiple correlation coefficient	0.3113
Residual standard deviation	50.1306

Table 6. Least squares multiple regression comparing carbohydrate intake and RPE by mileage

There is an R-squared value of -0.03210 when looking at the correlation regression of carbohydrate intake and RPE by mileage, therefore, indicating no relationship between the independent and dependent variables.

CHAPTER 5

DISCUSSION

Summary

The goal of this study was to determine the relationship between runners' in-race hydration and nutrition habits and their feelings of exertion throughout a 26.2-mile race. While a significant amount of data exists regarding the relationship between hydration/nutrition and race finishing time (Burke et al, 2005; Jeukendrop, 2004; Wilson et al, 2013), there is a lack of information about how runners' fuel affects their perceived exertion throughout a race. In order to answer what, if any, effect does marathon runners' amount of water intake and the amount of carbohydrate intake have on their level of perceived exertion throughout a 26.2-mile race, a web-based survey was provided to the runners of the 2014 Grandma's Marathon. Survey participants were asked to describe their fluid and carbohydrate intake throughout the race, as well as rate their perceived exertion using the Borg's Rate of Perceived Exertion (RPE) scale. Participants were given one week after finishing the marathon to complete the survey. Two hundred runners completed the survey, but only 113 surveys were included in the data analysis, as 87 of the surveys did not meet the inclusion criteria.

A multiple correlation regression was performed using SPSS and Excel, which compared carbohydrate intake to feelings of perceived exertion, and fluid intake to feelings of perceived exertion. As stated in Chapter 4 , no significant relationship was found between the runners' amount of fluid intake and their ratings of perceived exertion throughout the race. The significance level, or p-value, for this comparison was $p=0.9720$; thus, it was clear that no significant correlation exists. In addition, as discussed in Chapter 4, there was also no significant relationship between in-race carbohydrate intake and ratings of perceived exertion. The p-value for this comparison was p=0.7180, which also demonstrated no significant correlation. Thus, when analyzing the results of this study, one may establish that there is no significant relationship between amount of in-race fluid/carbohydrate intake and ratings of perceived exertion throughout a 26.2-mile race.

Limitations

Several limiting factors existed throughout this study. One limitation is the data was collected from the runners post-race. Thus, the information they provided may not have been completely accurate due to difficulty remembering details throughout the 26.2 mile race since participants were given one week post-race to complete the survey. When looking back at their levels of exertion throughout the race, runners may have recalled that their exertion was different than they truly felt at the time. For example, a runner may have answered that they felt a RPE of 11 at mile 13, when their actual RPE at that time was 14. Participants could have over or underestimated their RPE scores depending on their finishing time. If a participant had a “good race” or achieved a personal record finishing time, s/he could have a skewed recollection of their RPE throughout the race. Likewise, if a participant had a tough race, s/he could have recalled their RPE worse than they actually felt. In addition, since survey participants completed the survey post-race, they may have had difficulty accurately recording their fluid and CHO intake causing them to estimate the amount of fluid intake reported in the survey. For instance, a runner may have recalled that she drank four ounces of Powerade Ion4 at mile five, when she actually only drank two ounces. If participants would have had a means to complete the survey during the race, it may have been easier for them to correctly document their intake throughout the race. Therefore, the fact that they surveys were completed after the race posed multiple limitations.

In addition, the fact that the surveys were conducted by self-reporting also represents a limitation of this study. Participants in this study were required to report their own intake and feelings of exertion throughout the race; thus, they had the ability to adjust their answers as they saw fit. Participants may have falsely recorded their exertion as less than it actually was in order to avoid admitting that they were feeling significant fatigue or they may have remembered their level of exertion better than it actually was during the race. Also, participants may have documented ratings of perceived exertion that they believed researchers would expect from individuals running a marathon. For instance, runners may have recorded that their level of exertion was slowly increasing until the end of the race simply because they assumed that this trend was supposed to occur. The likelihood of this limitation is demonstrated as the average participant reported RPE scores gradually increased throughout the duration of the race. This is illustrated below in Figure 1. These limitations related to the post-race, self-reported survey collection consequently sacrifice some of the validity and reliability of the study.

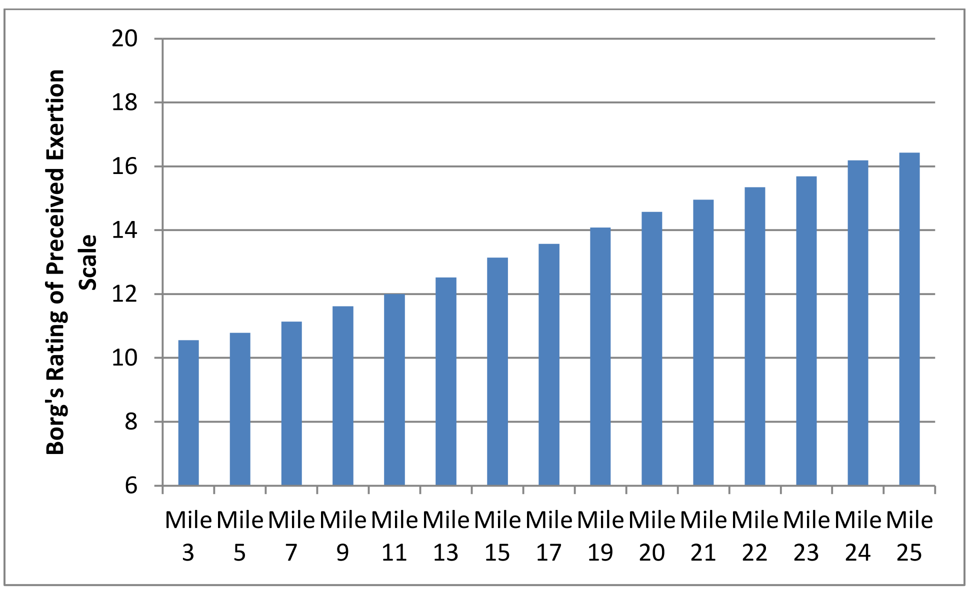

Figure 1. Average participant reported Borg's Rating of Perceived Exertion scores at mile markers throughout the 26.2 mile race

Another limitation with the self-reported survey is the associated assumptions required to calculate the amount of CHO and fluids participants consumed. As stated earlier, participants often reported their fluid intake in "cups." It was assumed that one "cup" was equivalent to four ounces as cups are often half-filled at hydration stations. However, participants may have consumed more or less than four ounces per reported "cup." It was also assumed that participants consumed the entirety of the CHO products they reported. However, they may not have completely consumed the whole product which may have skewed the data. Thus, the self-reporting nature of the survey created limitations for this study.

Further Research

While this study revealed that there is no significant correlation between hydration/nutrition and ratings of perceived exertion throughout a marathon, the results of this study have the potential to be applied to future research. For example, future researchers may question the relationship between pre-race nutrition/hydration and RPE throughout a marathon. They would have the opportunity to use the Borg's Rating of Perceived Exertion scale to monitor runners' exertion throughout the race; however, instead of analyzing its correlation with in-race hydration and nutrition, they would analyze how it relates to pre-race hydration and nutrition. Furthermore, future researchers could pose the same research questions present in this study, but alter the methodology to avoid the limitations of post-race self-reported data. Following a select group of runners throughout the race to watch and record their fluid and CHO intake and to record their ratings of perceived exertion in real time could offer more accurate data to answer the current research questions. Therefore, the results of this study and the research questions it answered may be applied to future research regarding marathon hydration and nutrition in relation to rating of perceived exertion.

Conclusion

In conclusion, the purpose of this study was to determine if a relationship exists between in-race nutrition and hydration and ratings of perceived exertion throughout a marathon. Two hundred runners of the 2014 Grandma's Marathon in Duluth, MN completed a web-based survey after finishing the race. The survey asked participants to describe their fluid and carbohydrate intake throughout the race, as well as rate their exertion using the Borg's Rating of Perceived Exertion scale. Data reduction and analysis was performed using the 113 surveys met the inclusion criteria. A multiple correlation regression was performed to compare fluid intake to ratings of perceived exertion, and carbohydrate intake to ratings of perceived exertion. Both calculations revealed p-values significantly greater than 0.05; thus, it was concluded that there is no significant relationship between fluid and carbohydrate intake and ratings of perceived exertion throughout a marathon. This study was limited by the fact that participants were required to self-report information after race completion. Runners' may have had difficulty recalling accurate information, or may have changed their responses based on what they believed was appropriate. Thus, future studies may address these limitations, as well as build on these research questions and the results of this study.

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Appendix A

1. What is your gender?

SurveyMonkey Audience

○ Female

○ Male

2. What is your age?

3. How many weeks did you train for Grandma's Marathon 2014?

4. Was this your first full marathon?

○ Yes

○ No

5. What was your finishing time (hour:minute:seconds)? If you did not finish please answer N/A.

6. Which of the following products did you consume during the race?

☐ CLIF Shot Energy Gel

☐ CLIF Shot Block

☐ GU Energy Gel

☐ Jelly Belly Sports Beans

Other (please specify)

7. Please describe the amount of the product(s), selected in question 6, you consumed throughout the race, including mile markers where the product was consumed. (Example: I consumed two Clif Shot Bloks at miles 6, 13, and 22. I consumed one Clif Shot Energy Gel packet at mile 17.)

8. Which of the following fluids did you use to hydrate throughout the race?

☐ Water

☐ Powerade with Ion4 (provided at water stations)

Other (please specify)

9. Please describe to the best of your ability the amount of fluid(s), as selected in question 8, you consumed throughout the race, including mile markers. Amounts may be described as cups or ounces. (Example: I consumed one cup of water at miles 3, 5, 9, 15, 17, 22, and 24. I consumed one cup of Powerade Ion4 at miles 11, 19, and 23. I also consumed 4 ounces at mile 14 and mile 25 from my personal water bottle.)

10. Please indicate your Rate of Preceived Exertion (as described by Borg's Scale) at the following mile markers.

	RPE 6 (No Exertion)	RPE 7 (Extremely Light)	RPE 8	RPE 9 (Very Light)	RPE 10	RPE 11 (Light)	RPE 12	RPE 13 (Somewhat hard)	RPE 14	RPE 15 (Hard)	RPE 16	RPE 17	RPE 18	RPE 19 (Extremely Hard)	RPE 20 (Maximal exertion)
Mile 3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 5	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 7	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 9	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 11	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 13	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 15	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 17	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 19	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 20	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 21	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 22	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 23	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 24	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Mile 25	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Appendix B

Informed Consent

You are invited to participate in a study of marathon runners' nutrition and hydration strategies in relation to perceived exertion. We hope to gain insight into how the in-race hydration and nutrition strategies of marathon runners affect their perceived exertion throughout a 26.2 mile race. You were selected as a possible participant in this study because you are a participant of the 2014 Grandma's Marathon. This is student thesis research at Bethel University's Physician Assistant Program.

If you decide to participate, we will ask you questions regarding demographics such as age, gender, and 2014 Grandma's Marathon finishing time, in-race carbohydrate intake, in-race hydration, and ratings of perceived exertion. The survey will take approximately 15 minutes and consists of 10 questions total. Data will be collected via SurveyMonkey and transferred to SPSS for data analysis.

Any information obtained in connection with this study that can be identified with you will remain confidential and will be disclosed only with your permission. In any written reports or publications, no one will be identified or identifiable and only aggregate data will be presented. Survey responses and data analysis will be securely stored within Bethel's Physician Assistant Program for a minimum of 5 years.

Your decision whether or not to participate will not affect your future relations with Bethel University in any way. If you decide to participate, you are free to discontinue participation at any time without affecting such relationships.

This research project has been approved by our research advisor in accordance with Bethel's Levels of Review for Research with Humans. If you have any questions about the research and/or research participants' rights or wish to report a research- related injury, please contact Kristine Baumann at krb22287@bethel.edu, Kaitlyn Proulx kap45245@bethel.edu, or Dr. Donald Hopper, Ph.D., AC SM-RCEP at dlh65773@bethel.edu.

By hitting 'Next" and completing survey, you are granting consent to participate in this research.

Appendix C

Borg's Scale of Perceived Exertion

While doing physical activity, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.

Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number from below that best describes your level of exertion. This will give you a good idea of the intensity level of your activity, and you can use this information to speed up or slow down your movements to reach your desired range.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number.

6 No exertion at all
7
Extremely light (7.5)
8
9 Very light exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes.
10
11 Light
12
13 Somewhat hard exercise, but it still feels OK to continue.
14
15 Hard (heavy)
16
17 Very hard. Very strenuous exercise. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.
18
19 Extremely hard. Extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.
20 Maximal exertion

Physical Activity for Everyone: Measuring Intensity: Perceived Exertion | DNPAO | CDC. (2011). Retrieved from www.cdc.gov/physicalactivity/everyone/measuring/exertion.html