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MARATHON RUNNERS AND THEIR NUTRITION VIEWS, PRACTICES, AND SOURCES OF NUTRITION INFORMATION

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ABSTRACT

Participation in marathons has been on the increase. However, research on the dietary and hydration practices of marathon runners is scarce and little is known about their views on the credibility of various sources of nutrition information. The purpose of this study was to investigate marathon runners' sources of nutrition information, practices surrounding nutrition, and perceived credibility of various sources of nutrition information. This study used an online, self-administered survey. Participants were recruited using email and social media outlets through the electronic mailing lists from two running stores and using the contact information for participants of two large marathon races. The data were analyzed using descriptive statistics and chi-square tests. This study included 403 participants, 61% of which were female. The mean age was 38.2 ± 10.4. The main sources of nutrition information for marathon runners were friends (57.3%), magazines (44.7%), websites (32.0%) and coaches (25.8%). Registered dietitian nutritionists (RDNs) and dietetic technicians, registered (DTRs) were rated highest in the category of "very reliable" (39.1%). Most runners (72.7%) look for nutrition recommendations to increase energy. Some marathon runners use outdated practices, including 18.4% using a depletion phase before carbohydrate loading, which is a potential area for reaching and educating this population. Significantly more women look for information regarding weight loss than men ($p<0.001$). RDNs and DTRs wishing to provide nutrition education for marathon runners can focus on providing and recommending reliable sources of information based on clients' interests and needs.

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PART I: LITERATURE REVIEW

Introduction

Interest in running has been increasing over the past few decades, and marathon running is no exception. To many marathon runners, qualifying for the Boston Marathon is a great achievement. To participate in this race, runners must meet a qualifying time or participate with a charity[1]. The race not only attracts recreational runners, but elite runners from all over the world as well. The number of entrants in the Boston Marathon has been rising for many years. Between 1997 and 2011, the number of runners who participated in the Boston Marathon more than doubled, to over 26,000 entrants[1]. Other major marathons have also experienced increases in the number of participants including the Chicago Marathon[2] and the New York City Marathon[3]. In addition, the Nationwide Children's Hospital Columbus Marathon has more than doubled since 2006[4]. The Indianapolis Monumental Marathon also has seen very large increases in the number of registrants since it began in 2008[5]. As is evident, marathon participation has been increasing greatly in the past several years.

Nutrition is an extremely important aspect of marathon running, for both performance and safety. One health threat that may occur during a marathon is hyponatremia. This condition is classified as serum sodium levels below 120 mmol/L[6]. Hyponatremia causes various symptoms, ranging from vomiting, fatigue, and headache to pulmonary and cerebral edema, seizures, and death[7]. Almond, et al[6] found that approximately 13% of finishers of the 2002 Boston Marathon had hyponatremia. Factors that increase the likelihood of hyponatremia include excess fluid intake, a slow race time, and being female[6]. Thus, hyponatremia may impact many runners who have little experience or training due to slower race times.

Dehydration can also occur, especially in hot conditions. Dehydration decreases blood volume, which translates to decreased cardiac filling and output[8]. With decreased cardiac output, less blood is supplied to the skeletal muscles, brain, and heart, which may lead to decreased performance[9]. Dehydration can also inhibit the body's cooling mechanisms, possibly resulting in hyperthermia[8]. Dehydration and hyperthermia may lead to premature fatigue during endurance exercise. The risk of these impairments increases in hot, humid temperatures when heat dissipation through sweating is compromised. Therefore, taking preventative measures is important in these situations[9].

Dehydration and inadequate electrolyte levels are also associated with other heat illnesses. These include heat cramps, heat exhaustion, and heat stroke[7]. Heat cramps can be painful but can be treated relatively easily by replacing fluids and electrolytes lost in sweat and stretching the affected muscles[7]. Heat exhaustion and heat stroke are more severe heat illnesses. Both conditions occur more frequently in hot and humid environments, and may be difficult to distinguish between. Heat exhaustion is less severe, with a body temperature generally between 97°F and 104°F[7]. Symptoms of heat exhaustion include dizziness, headache, nausea, and muscle cramps[7]. Heat stroke is the most severe type of heat illness, and is associated with body temperatures above 104°F and poses a greater risk to health. Indicators of heat stroke include rapid heartbeat, hypotension, vomiting, altered mental status, seizures, and coma. If gone untreated, heat stroke can be fatal[7]. Since marathon runners are running an average of approximately 4.5 hours[10], dehydration and decreased heat loss mechanisms may be problematic and can contribute to heat illnesses. Since inexperienced runners often take longer during events, they are at higher risk of many consequences due to slower race times. Therefore, it is important

for marathon runners to understand how best to hydrate, fuel, and maintain body temperature during training and races.

Although it is rare, people die every year during or due to participation in marathons[10]. Most deaths occur due to myocardial infarction, coronary atherosclerosis, and unspecified cardiac arrest[10]. These causes have multiple contributors and may not be preventable through proper hydration and nutrition during the event. However, some other causes of death are preventable, including hyponatremia and heat stroke[10]. With increased participation among novice runners, deaths might be expected to rise because some runners are not aware that some of the causes and contributors are preventable. Fortunately, the rates of death during and due to marathons have not increased significantly. The rate of deaths in marathons between 2000 and 2009 was 0.75 per 100,000 finishers[10]. Although the death rates remained unchanged, nutrition is still an extremely important aspect of safety and performance in marathons, especially for less experienced runners.

Recommendations regarding nutrition for endurance sports have been around for several years and there are many sources of nutrition guidelines. The Academy of Nutrition and Dietetics (formerly the American Dietetic Association) published a position paper in 2009 regarding nutrition for athletics[11]. Since this was developed by registered dietitians in collaboration with the American College of Sports Medicine, this is a credible source of nutrition information for athletes. However, many of the available resources are not as reliable as this document. A simple search of "marathon nutrition" in a search engine results in thousands of websites that contain nutrition information and guidelines for marathon runners, including livestrong.com[12], active.com[13], and runnersworld.com[14]. A multitude of magazines and books

also provide abundant information regarding nutrition for marathon runners. These may or may not contain accurate information, and caution should be taken when referencing these.

Nutrition Considerations for Marathons

Marathon runners need a diet similar to that of the average individual, but they may need to increase their total intake to maintain body weight and composition, and receive adequate nutrients[11]. Without adequate nutrition, a runner will not be able to run at their greatest potential. Recreational runners may have little training in running and nutrition, which could increase their chances of suffering from preventable, nutrition-related consequences. Therefore, it is important to evaluate dietary habits among recreational marathon runners to prevent these consequences, promote general health, and improve performance.

All three macronutrients are essential in metabolism and play key roles in endurance sports. The recommended macronutrient distribution ranges are the same for athletes and the general public: protein should account for 10-35% of daily energy, fat should account for 20-35% of daily energy, and carbohydrates should account for 45%-65% of daily energy[15]. In addition to the recommended range, the recommendation for protein is often expressed as the number of grams of protein needed per kilogram of body weight per day. For the general public, the recommended amount is 0.8 g/kg body weight; for endurance athletes this level is increased to 1.2-1.4 g/kg body weight[11].

Carbohydrates play a very important role in homeostasis and metabolism in endurance activities. Carbohydrate in the forms of muscle glycogen and blood glucose are the two major fuels used by muscles[16]. Providing the body with adequate carbohydrate before, during, and after a run or marathon is important for performance. Carbohydrate is stored as glycogen in muscles

and the liver. When needed, glycogen from these muscle and liver is broken down to be used as fuel in the body. Glycogen storage can be maximized through carbohydrate loading to provide the body with adequate energy. Consuming exogenous sources of carbohydrates during events and long training runs can also help provide the body with adequate carbohydrate for the event. Together, carbohydrate loading and consuming carbohydrate during endurance exercise can help delay fatigue and enhance performance. Consuming adequate carbohydrates after endurance exercise can help to ensure that muscles are repaired properly[11].

Since muscle glycogen is such an important aspect of performance, carbohydrate loading before a race is important for endurance athletes to maximize these stores. The basis behind carbohydrate loading is to maximize glycogen stores in the muscle to delay fatigue during endurance events[17]. Carbohydrate loading has been a common practice since the 1960s[17]. Previously, it was thought that a glycogen depletion phase of three to four days preceding a carbohydrate loading phase of three to four days was needed before the event[17]. After more research, it was determined that the depletion phase of carbohydrate loading was unnecessary to achieve maximal glycogen storage[18]. In addition to the depletion phase being unnecessary, research has shown that only one day of high carbohydrate intake is required to reach near maximal glycogen stores in the muscle[18]. Currently, the general recommendation for carbohydrate loading is to increase carbohydrate consumption the day before an event and decrease or avoid exercise[17,18].

Carbohydrate loading and consuming a pre-race meal high in carbohydrates will allow a person to run for longer durations before fatiguing[11,16]. One study reported that runners who consumed more than 7 g/kg body weight of carbohydrates the day before a race performed better than those who consumed less carbohydrates[19]. Consuming carbohydrate before a race is also

important in replacing glycogen lost during an overnight fast and helps to maintain blood glucose during a race[20]. There is controversy over whether low glycemic index (GI) foods should be consumed in this time frame[28]. Theoretically, low GI foods will provide a more sustained supply of glucose to the body compared with high GI foods[20]. Some studies have shown that consuming low GI foods before exercise improves endurance performance[21,22]. Other research did not show an improvement in endurance performance with a low GI meal before exercise[23]. Additionally, another study demonstrated that when carbohydrate is consumed during exercise, the GI of the pre-event meal does not play a significant role in endurance performance[24]. These studies use different amounts of carbohydrate at different amounts of time before exercise, so results are difficult to interpret. Therefore, more research needs to be done on the use of the glycemic index for marathons.

Carbohydrate consumption during a marathon is also important. This may help delay fatigue and thus enhance performance[25]. Exogenous carbohydrates help maintain blood glucose levels, which allows this glucose to be available for utilization in the muscles[26]. In addition, exogenous carbohydrates help to spare muscle glycogen so less is utilized[27]. Theoretically, slower oxidation of glycogen should allow this fuel source to be available for a longer time. The enhancement of carbohydrate oxidation seems to be a dose-related response, with higher amounts of carbohydrate ingestion correlating with higher oxidation, up to a maximal threshold[27]. Sports drinks, such as Gatorade® and Powerade®, are often recommended as a source of exogenous carbohydrates. These products also aid in replacing water and electrolytes lost during prolonged exercise and therefore may be beneficial in multiple ways. Sports drinks and their effect on performance have been the subject of research studies[25,28]. The results indicate that commercially available sports drinks may be beneficial to performance[25,28]. There are also

many other products available to provide athletes with carbohydrate and electrolytes during exercise, including gels and bars. These will be discussed in a later section.

As was previously mentioned, endurance athletes, including marathon runners, may need more protein than the average individual to help in recovery[11]. For the general public, the recommended daily allowance for protein is 0.8 g/kg body weight, but this may need to be increased to 1.2-1.4 g/kg body weight for endurance athletes[11]. Protein is needed in higher amounts for athletes to maintain nitrogen balance, to repair muscles after exercise, and to a much lesser extent as fuel during exercise[11,29]. Although endurance athletes need slightly more protein than the average American, a typical diet provides more than adequate protein. Therefore, this amount of protein should be relatively easy to achieve through a normal diet, and supplements are not necessary for most athletes.

Protein is also important during recovery from endurance exercise. Consuming protein providing the essential amino acids can increase fractional synthetic rate (FSR) of skeletal muscles and positive protein balance[30,31]. Thus, consuming protein during recovery from endurance training is important in muscular adaptations to exercise.

Adequate carbohydrate consumption after endurance activities is also extremely important for recovery. Consuming enough carbohydrates after exercise aids in sparing muscle and dietary protein, allowing muscles to be repaired[11]. Consuming a combination of carbohydrate and protein enhances muscle fractional synthetic rate (FSR) to a greater extent than carbohydrate alone, which reflects increased muscle turnover and repair[30,31]. Therefore, both carbohydrate and protein should be consumed after endurance training and competition events to replenish glycogen stores and repair muscles damaged during exercise.

Fat plays many important roles in the body. It is utilized as a source of energy in prolonged exercise. Since marathon runners exercise for prolonged periods of time, fat is a necessary part of their diet. In addition, fat provides the means for delivery of many necessary micronutrients, such as vitamins A, D, E, and K. Vitamins are important mediators of metabolism, immune function, cellular maintenance, and many other functions[11]. Therefore, they are an essential part of the diet. A diet that provides 20-35% of calories from fat should be adequate to provide necessary vitamins and fuel for marathon runners[11].

Hydration is also an important aspect of nutrition and performance. It is recommended that endurance athletes strive for euhydration prior to, during, and after exercise[11,16]. Athletes should strive for euhydration at least four hours before training or an event[11]. During the race, fluids are often combined with carbohydrates and electrolytes. This provides carbohydrates for fuel and replaces electrolytes and fluid lost in sweat. In addition, electrolytes and carbohydrates help enhance absorption of the fluids[16]. In this sense, sports drinks containing electrolytes and carbohydrates are beneficial in maintaining fluid and electrolyte balance as well as providing exogenous carbohydrate. Multiple transporter carbohydrates may play a role in absorption as well and some research suggests that consuming glucose and fructose during endurance events can increase absorption further than glucose alone[11,16]. Therefore, sports drinks may aid in providing fuel, replacing electrolytes and fluid, and aid in absorption.

Electrolytes are an important aspect of nutrition to consider for marathon runners. Electrolytes, such as sodium and potassium, play a key role in muscle function. When levels are too high or too low, people may suffer severe consequences including collapse, heat-related illness, and muscle cramps[7,32]. Sodium and potassium are lost in sweat and athletes may lose large amounts of these electrolytes during endurance exercise and must be sure to replace these.

Sports drinks containing electrolytes are widely available and can help marathon runners maintain electrolyte levels.

The requirements for most vitamins and minerals are not increased for athletes. In addition, due to overall increased intake, endurance athletes such as marathon runners often meet or exceed the Dietary Reference Intakes for many vitamins and minerals[20]. In general, a diet providing a variety of nutrient-dense foods should supply most micronutrients athletes need. However, there are a few key micronutrients that endurance athletes should be aware of. Iron is especially important in exercise, because it is a key component of hemoglobin and myoglobin. If an athlete develops iron-deficiency anemia, the most common deficiency in the world[33], performance will suffer[20]. Iron is also required in some of the metabolic pathways utilized during exercise. Women should be especially aware of iron intake and status, because they are at higher risk of developing an inadequacy or deficiency[20]. There are four stages of iron deficiency, the first of which is iron depletion. At this point, iron stores have decreased but hemoglobin levels are maintained. While this does not decrease the VO_{2max} that can be achieved, performance will suffer because iron levels in tissues are decreased. Iron is necessary for aerobic metabolism in the cells, so decreased levels will negatively impact performance[20]. Iron depletion can be tested with plasma ferritin levels, which indicates the amount of iron in tissues.

Calcium and vitamin D are also of importance to marathon runners. If inadequate calcium and vitamin D are consumed, an individual may be at increased risk for low bone mineral density and stress fractures[20]. Stress fractures affect many athletes, and tend to affect runners frequently[34]. In addition, women are at higher risk of developing stress fractures, which is associated with multiple factors including lower bone mass, anatomical structure of bones, and dietary intake[34]. Low serum 25-hydroxy vitamin D levels and low calcium intake are associated

with increased rates of stress fractures[34,35]. Calcium helps prevent bone loss in the femur, which is a protective factor for stress fractures[36]. Therefore, a diet and lifestyle providing adequate calcium and vitamin D can help individuals prevent stress fractures.

Exercise is a stressor in the body and leads to increased oxidative stress. Therefore, it would be expected that antioxidant supplementation, such as vitamins C and E, are important in combatting this stress in the body and there is a large amount of research regarding oxidative stress and exercise[37-39]. Multiple studies have found that training stimulates the body's endogenous mechanisms of dealing with oxidation[37-39]. The reactive oxygen species that are produced during exercise help to turn on the genes that are responsible for creating the proteins for various antioxidant enzymes, including superoxide dismutase and peroxidases[38]. Other research has shown that these endogenous adaptations are reduced when antioxidant vitamins C and E are supplemented, which consequently decreases endurance capacity[37,39]. Therefore, supplementation of vitamins C and E is not recommended and marathon runners should try to consume adequate amounts from the diet.

As was mentioned previously, most vitamin and mineral needs are not increased for athletes and a balanced diet high in nutrient-dense foods should provide adequate amounts of most vitamins and minerals. This can also be said for the general public, but dietary supplements are still used by about half the US population[40,41]. In general, women are more likely to use dietary supplements than men, as well as people who have overall healthier lifestyles including increased exercise, abstention from smoking, and moderate alcohol consumption[41]. Of all dietary supplements, multivitamin and multimineral supplements are the most commonly used, followed by calcium, and omega-3 and fish oil supplements[41]. There are a variety of reasons people use

dietary supplements, but the most common reasons are to improve or maintain health[41]. Although they are widely used, the efficacy of dietary supplements remains elusive[41].

Current Research in Endurance Athletics

Recently, there has been an increase in research regarding carbohydrate consumption during prolonged exercise to explore whether consuming multiple transporter carbohydrates during exercise can delay fatigue more so than consuming glucose alone. The theory behind using multiple transporter carbohydrates takes advantage of the different transporters needed to absorb glucose and fructose into enterocytes[42]. Transport channels in the intestinal cells become saturated at high rates of glucose ingestion, but the use of carbohydrate molecules that require different transport molecules will enhance total carbohydrate absorption by utilizing multiple transporters. Also, consuming multiple transporter carbohydrates may enhance gastric emptying and subsequently contribute to better carbohydrate and water absorption in the small intestine[43]. Enhanced absorption of carbohydrates may lead to increased exogenous carbohydrates being utilized as fuel during endurance exercise, which can spare glycogen[27,42]. Theoretically, both enhanced absorption and increased exogenous carbohydrate utilization should improve performance in endurance events. Much of the research done in this area involves very small sample sizes with only about 8-12 subjects each[22,38,39], so more research is necessary to determine whether or not consuming multiple transporter carbohydrates is beneficial to endurance performance.

Another recent research interest in endurance sports is whether training with high or low glycogen stores is better for performance. The idea behind training with low carbohydrate stores is that the body will oxidize a greater percentage of fat, which can provide a greater amount of energy[44]. To implement this type of training diet, athletes would consume a diet lower in

carbohydrate than is generally recommended. Research done in this area has shown that there are no benefits to training with low carbohydrate stores[44,45]. One study found that training with high carbohydrate stores increased the amount of exogenous glucose oxidation during exercise[45]. Therefore, exogenous sources of carbohydrate during an event would be extremely important in maintaining performance. Overall, the results of these studies support the current recommendations to consume adequate carbohydrates during training and to carbohydrate load before an event.

Dietary Supplements and Ergogenic Aids

The creation of new products and supplements has also influenced nutrition for endurance athletes. There are many sports drinks, gels, bars, and chews on the market. These provide a combination of some or all of the following: carbohydrates, protein, electrolytes, caffeine, antioxidants, vitamins, and minerals[46-48]. Vitamin and mineral supplements may or may not be marketed toward athletes specifically, but according to the Academy of Nutrition and Dietetics, athletes do not need to take these supplements as long as they are consuming enough calories from a variety of foods[11]. Some of these products may be beneficial to marathon runners, but many may not lead to advertised results[29]. In addition, these products are often costly and may take advantage of people who believe they will work, when in fact there may be no scientific evidence of the supplements being beneficial[29].

Sports drinks are often promoted to endurance athletes. These products often contain carbohydrates and electrolytes, in addition to fluid. As was previously discussed, consuming carbohydrates during endurance exercise can help delay fatigue. Electrolytes help maintain fluid balance in the body and also play a role in muscle function. Electrolytes and fluid are important to prevent collapse during or after a marathon and decrease the likelihood of suffering from heat-

related illnesses[7,11]. Therefore, sports drinks containing carbohydrates and electrolytes are products that may be beneficial for endurance athletes.

Gels, bars, and candy-type products are also often promoted to endurance athletes as an alternative to sports drinks. Many of these contain some of the same components found in sports drinks, such as carbohydrates and electrolytes. These may help maintain performance in endurance events. A downside of these products is that they do not contain any water or fluid as sports drinks do. Therefore, it is necessary to consume them with water to optimize absorption and hydration status[46]. It is important to remember that there is a maximal uptake rate of carbohydrate[20], so consuming these products with sports drinks may provide a high concentration of carbohydrate, which may result in delayed gastric emptying. Recommendations regarding quantity and frequency of their use will be discussed in a later section. These products also may contain other ingredients such as caffeine and vitamins, with varying effects[46,47].

Caffeine may enhance performance during endurance exercise such as marathons[11,16,29]. Performance improvement is thought to be a result of caffeine's stimulant effects and decreased perceived effort[11]. Effects of caffeine may vary depending on the amount of caffeine consumed, as well as typical caffeine intakes outside of exercise. Consuming 3 mg of caffeine per kilogram of body weight enhances performance in time trials[49]. Time trials suggest a dose-response to caffeine ingestion up to approximately 3 mg of caffeine per kilogram of body weight; increases in caffeine intake beyond this do not produce greater effects on performance[49]. Additionally, there is an attenuated effect on people who habitually consume caffeine compared with people who do not[50]. The duration of the ergogenic effect of caffeine is also diminished in habitual caffeine users[50]. Therefore, the ergogenic effect of caffeine will depend on the individual and the amount consumed.

Caffeine also may have a role in recovery from endurance activities. In non-caffeine consumers, 8 mg caffeine per kilogram of body weight combined with 4 g carbohydrate per kilogram of body weight consumed during recovery can greatly enhance glycogen resynthesis compared with carbohydrate alone[51]. This is thought to be related to the increased levels of insulin associated with ingesting caffeine and carbohydrate[51]. Research has been inconclusive regarding the use of vitamins to enhance performance during exercise[37,52-54]. Therefore, products containing vitamins are not recommended. The carbohydrates, caffeine, and electrolytes in sports drinks, gels, and chews may help to maintain or enhance exercise performance, but other ingredients, such as vitamins and herbs, in these may not aid in performance.

Nutrition Recommendations for Training and Marathons

Nutrition Before a Run

Before a run or race, carbohydrates and fluids are of most importance. About four hours before a run, fluids should be consumed to try to achieve euhydration and urination before the run[20]. This should consist of approximately 5-7 ml of fluids per kilogram of body weight, which is about 1 ounce per pound of body weight[20].

Carbohydrates should also be consumed no more than four hours before a run to try to promote glycogen storage, which is especially important after an overnight fast. Between 1.0-4.0 g of carbohydrate per kilogram of body weight should be consumed to try to increase glycogen stores, depending on the amount of time until the run[20]. When it is closer to four hours before a run, more carbohydrate should be consumed; when it is closer to the time of the run, less carbohydrate should be consumed[20]. In addition, a liquid source of carbohydrate closer to the time of the race may be beneficial because of faster gastric emptying[20]. Many people may not consume breakfast before a run. Although not ideal, approximately 30 grams of carbohydrate

should be consumed a few minutes before the run to try to increase exogenous glucose in these situations[20].

Nutrition During Runs

Nutrition during runs depends on the duration of the run. For events lasting 2.5 to 3 hours, up to 80-90 grams of carbohydrate per hour should be consumed, consisting of multiple transporter carbohydrates to maximize absorption[20,26]. However, this needs to be assessed on an individual basis because individuals may have different responses to consuming this amount of carbohydrate[26]. When one type of carbohydrate is consumed, the maximal absorption rate is approximately 1 gram per minute. This is enhanced to about 1.7 grams per minute when multiple types of carbohydrates are consumed[20]. In addition, consuming multiple types of carbohydrate can enhance gastric emptying[43]. As a result, a greater amount of carbohydrates can be taken up and utilized for fuel during the exercise.

Depending on the intensity of exercise, different forms of carbohydrate can be consumed. During marathons, carbohydrate beverages, gels, and chews may be easiest to consume. These should be consumed starting within the first hour of exercise and every 15 to 20 minutes thereafter to maintain blood glucose levels and provide the working muscles with adequate energy[20]. Therefore, about 25 to 30 grams of carbohydrate should be consumed every 20 minutes. Most carbohydrate gels and chews provide about 25 grams of carbohydrate per serving[55,56], so this translates to one serving every 20 minutes.

Nutrition for Recovery

Nutrition in the period of time following training or competition is extremely important. A variety of nutrients are needed during this time, including carbohydrate, protein, fluid, and electrolytes. Directly following exercise, the muscles are able to take up more glucose and store

it as glycogen compared with other times due to the increased GLUT 4 receptors on the surface of muscle cells[57]. In addition, muscle damage that occurred during the exercise needs to be repaired so the muscle can adapt and maintain or increase its strength; this process requires amino acids. Following endurance exercise, the body needs both carbohydrate and protein in approximately a 4:1 carbohydrate to protein ratio[20]. Food or carbohydrate-protein beverages should be consumed within 30 minutes after exercise ends and every 15-30 minutes thereafter for several hours.

Carbohydrates are essential in replenishing glycogen stores in muscles following endurance exercise. How aggressively carbohydrate is consumed depends on the exercise and the time of the next event. For example, if an individual partakes in a long training run that depletes glycogen stores and will be running again within 24 hours, nutrition is critical to replenish glycogen. Another scenario in which nutrition is critical during recovery is if an individual is participating in Goofy's Race and Half Challenge in which individuals run a half marathon one day and a full marathon the next[58], nutrition during recovery is extremely important. In these cases, 1-1.2 grams of carbohydrate per kilogram of body weight should be consumed every hour for four hours following endurance exercise. Protein is also important in providing amino acids to repair damaged muscles and cells. Fifteen to 25 grams or approximately 0.3 grams of protein per kilogram of body weight per hour should be consumed in the time immediately following exercise[20]. Combined, carbohydrate and protein recommendations translate to about a 4:1 ratio of carbohydrate to protein. Too much protein should be avoided because it delays gastric emptying and will therefore delay delivery of nutrients to muscles where they are needed. Over a 24-hour period following endurance exercise, carbohydrate, protein, and energy need to be adequate to promote glycogen synthesis and muscle recovery.

Fluid and electrolytes are also important during recovery from endurance exercise such as marathons. Large amounts of fluid and electrolytes can be lost during prolonged exercise if they are not consumed adequately throughout. One method of gauging how much to drink after a run is to weigh oneself before and after to determine weight loss. For every pound lost, an individual should consume about 24 fluid ounces to rehydrate. Although common after many running events, alcoholic beverages should be used with caution. Alcohol consumption may displace adequate carbohydrate intake during the recovery period, which could lead to decreased glycogen resynthesis[59]. In addition, alcohol may play a role in decreased muscle protein synthesis[60]. Beverages containing sodium and other electrolytes should be consumed. These can help stimulate thirst and aid in retaining fluids consumed[20].

Need for Research

Since nutrition is such a crucial part of marathon running, it is important for these athletes to be aware of and understand the nutrition guidelines. Knowing where the information is coming from and how to implement these guidelines is also important for both safety and performance during marathons. Every year, people collapse during marathons due to nutrition-related causes[8] and some may die[10]. Many of these events can be prevented by proper education and implementation of nutrition guidelines.

There are many fitness and running magazines and websites that offer nutrition information for marathon runners. One popular magazine is Runner's World[14]. Registered dietitians write many of the nutrition articles in this magazine and there is a column titled "Ask the Sports Dietitian"[14]. With a registered dietitian as a primary reference, this information is likely to be a credible source of nutrition information for runners. There are many other websites and books with nutrition information for marathon runners as well. The credibility of these is

questionable. Depending on the author's credentials and the research supporting the nutrition advice, the information may or may not be the best and most up-to-date. With improper nutrition and training advice, health and performance may be compromised. For any professional working with athletes, it is important to provide accurate and useful information.

Currently, there is no research on marathon runners' sources of nutrition information. There have been studies on where people get general nutrition information, but less research has been done for marathon runners. One study in Canada looked into people's sources of nutrition information. This study found that most people get nutrition information from magazines, books, and the Internet. Also of importance, this study found that dietitians were seen as the most reliable source of nutrition information[14]. In 2008, the American Dietetic Association (now the Academy of Nutrition and Dietetics) completed a survey of Americans' sources of nutrition information and views of the credibility of various sources. They found that television, magazines, and the Internet are the three main sources of nutrition information. Again, registered dietitians were seen as the most credible sources of nutrition information. Physicians and nurses were the second and third most credible sources, respectively[61]. The results from these two surveys are promising and show that consumers value nutrition information from registered dietitians. However, more research needs to be done as consumer trends and technology continue to change.

Another study investigated runners' views and practices regarding hydration. This study found that athletes with greater experience, training, and performance levels consume more sports drinks and believe they are beneficial to performance when compared with athletes in lower categories. This same study found that only 20% of runners monitor their hydration status[62]. Hydration and electrolyte balance is extremely important in runners' safety and

dehydration contributes to collapse during a marathon[8]. As 80% of runners do not monitor hydration, this demonstrates the need to properly educate endurance athletes in hydration practices.

Before providing information to marathon runners, current knowledge and practices of this population must be understood. Marathon runners may not perceive a need for better nutrition, or they may want more nutrition guidance but are not sure where to get credible information. This study will address marathon runners' sources of nutrition information, what they use this information for, and their views on the credibility of various sources of nutrition information. Information regarding basic training, nutrition, and hydration practices will also be collected to see if there are any relationships between these variables and nutrition information sources and views. The results will provide professionals, working with marathon runners, necessary information regarding how to best reach this population.

PART II: THESIS MANUSCRIPT

INTRODUCTION

Interest and participation in marathons has been increasing in the past several decades, and registration for many marathons show these changes[1-5]. Nutrition is an extremely important aspect of endurance events such as the marathon. Good nutrition can help improve health, safety, and performance of marathon runners. General health is improved by nutrition as it provides fuel for the body, protein for cells, and vitamins and minerals for optimal function.

Nutrition can help with the safety of marathon running by helping avoid preventable injuries and illness related to inadequate intake, such as dehydration, or excessive intake, such as hyponatremia. Dehydration is an important condition for marathon runners to be aware of, and can decrease performance and contribute to the development of more serious conditions including hyperthermia and heat illnesses[7-9]. Hyponatremia occurs when serum sodium falls below 120 mmol/L[6]. An estimated 13% of runners who finished the Boston Marathon had hyponatremia in 2002[6]. Risk factors for hyponatremia include excess fluid intake, slow race time, and being female. People with less experience and training may have slower race times, consume more fluids, and be at increased risk for hyponatremia.

Performance can also be improved by providing the body with adequate and appropriate fuel before, during, and after the activity. For example, carbohydrate loading can maximize glycogen stores and help endurance athletes continue their activity for a longer duration before becoming fatigued[11,16]. In addition, consuming carbohydrates during a training run or race is important in maintaining blood glucose levels so the working muscles have adequate fuel[25].

There is an abundance of nutrition information available to consumers on the news and Internet. While some of this comes from credible sources, such as registered dietitian

nutritionists and dietetic technicians, registered (RDNs and DTRs, respectively), other information is less credible. Marathon runners looking for nutrition information need to be able to find current, credible information that will help them improve their health and performance in running. With the increasing popularity of marathons, it is important to try to provide evidence-based nutrition information to this group for their health and safety. Research is lacking in the area of nutrition knowledge and practices of marathon runners. Therefore, it is vital to understand their nutrition practices, the sources and types of nutrition information sought, and their perceptions of credible sources of nutrition information.

The purpose of this study was to investigate marathon runners' practices surrounding nutrition during training and races, sources of nutrition information, and perceived credibility of these sources of nutrition information. This study also looked at training method, nutrition practices during training and previous races, and the types of nutrition information they are looking for. In addition, relationships between gender, age, marathon experience, type of training and source of nutrition information were explored.

METHODS

This was a cross-sectional study that used a convenience sample of participants who were recruited through four different outlets. The first two were Fleet Feet Sports retail athletic stores in Syracuse and Rochester, NY. These stores used Facebook and email newsletters to distribute the online survey link. The remaining two sources of participants were the Nationwide Children's Hospital Columbus Marathon and the Indianapolis Monumental Marathon. These races also used Facebook to recruit participants. Data collection occurred between June 26th and October 19th, 2013. In total, 658 subjects began the survey, and 403 completed the survey. Only completed surveys were included in data analysis. Due to the difficulty in estimating the number

of people reached by the call to complete the survey, it is difficult to determine the response rate for this survey.

Approval for human research was granted by the Institutional Review Board at Syracuse University before recruitment began. This study was deemed exempt under federal regulation. After an extensive search of the literature, no tool was identified to gather data from athletes regarding training, nutrition practices, and sources of nutrition information. Therefore, a survey was developed for use in this study. Individuals with experience in research and running reviewed the survey for content and clarity. Revisions were made based on their feedback prior to data collection.

The survey (See Appendix 1) was broken down into five sections: participant characteristics, training, dietary and hydration practices during training, dietary and hydration practices during race, and source of nutrition information.

Participant characteristic data included age, gender, height, average weight during training, and whether or not a vegetarian/vegan diet was followed. The training section included questions related to current training for a marathon, such as training method, frequency of runs, maximum mileage, and previous race experience. The sections regarding dietary and hydration practices during training and races included questions regarding carbohydrate loading, nutrient timing, types of foods and beverages consumed in pre- and post-run meals, and supplement use during training and races. Questions on nutrition information included the importance of nutrition for marathons, sources of information used, frequency of use, and reasons behind looking for nutrition information. Participants were asked to specify exact sources of information used under broad categories (e.g. if a magazine was used, which magazine).

The survey was developed and data were collected using Qualtrics® online survey software. Surveys were self-administered. Data were analyzed using IBM SPSS (version 21). The research study was mainly descriptive in nature, thus frequencies were the main analyses performed. Additionally, Pearson chi-square tests were done to determine if differences exited between demographic variables and nutrition and training practices.

RESULTS

PARTICIPANT CHARACTERISTICS

Participant characteristics of the whole sample and of the sample broken down by gender are found in Table 1. Of the 403 people that completed the survey, 247 were female and 156 were male. In addition, 14.1% of the participants were vegetarian or vegan.

TRAINING METHODS

Nearly half of participants trained for a marathon on their own, 28% trained with a friend, and 27% of marathon runners used an online training program. Approximately 22% were training with a running club. Participants were able to select more than one response, so the sum is greater than 100%. Most participants (98.5%) had previously participated in running races. In addition, 82.4% had previously participated in a half marathon and 61.5% had participated in a full marathon. A small percentage of participants (6.4%) had partaken in races greater than 26.2 miles.

TRAINING DIETARY AND HYDRATION PRACTICES

One hundred eighty two (45.2%) of the participants said they practiced carbohydrate loading before a long training run. Of those who carbohydrate load, 33 (18.1%) deplete their carbohydrates before carbohydrate loading. There was no significant difference in carbohydrate loading in training between first-time and experienced marathon runners ($p>0.05$).

Participants reported consuming pre-run meals at different times: 32.5% eat within one hour before, 43.4% eat two to three hours before, and 24.1% eat more than three hours before a training run. These meals consisted of a variety of different foods, with grains and fruit being the most frequently consumed foods. Most people (89.3%) drink water before a training run. A little more than a quarter of participants (27.3%) also drink some type of electrolyte drink before a training run. Other drinks that runners consumed before a training run included protein drinks, coffee, and fruit juice. Details regarding composition of pre-run meals can be found in Table 2. Nutrient timing after training runs varied as well. While most people consumed food within one hour (81.1%), the remainder consumed food more than an hour after a training run. After a training run, there was a greater variety of beverages consumed compared to beverages consumed before a training run and many people consume more than one type of beverage. Most people reported drinking water, and many people also drank an electrolyte beverage, a protein beverage, chocolate milk, or coffee after a run. A chi-square test for independence (with continuity correction) indicated no significant association between experience and the use of electrolyte drinks after a training run (χ^2 (1, n = 403) = 3.86, p = 0.050, phi = -0.103). The amount consumed was mainly based on thirst (76.4%), although some people used a few different ways to determine how much to drink, including urine color and a combination of multiple techniques including weight change, thirst, and experience. Foods consumed in post-training run meals or snacks are shown in Table 2.

RACE DIETARY AND HYDRATION PRACTICES

More people reported carbohydrate loading before a race (80.8%) compared to before long training runs (45.2%). Of those, about 18.4% reported using a depletion phase before carbohydrate loading. More than half of the runners who had previously participated in

marathons consumed a meal two to three hours before a race. Water was the most common pre-race beverage (86.6%), with electrolyte drinks following as the second-most common pre-race drink (37.3%). More information regarding meals surrounding races can be found in Table 3. Of the 276 participants who had previously participated in marathons, 76.8% consumed a meal within one hour after completing a race, 21.4% within two to three hours, and 1.8% consumed a meal more than 3 hours after finishing a race. A variety of foods were reported being consumed in post-race meals and snacks. Many more people consumed animal protein after a race than before a race (61.6% vs. 28.6%). Water and electrolyte drinks were the most common beverages consumed after races as well. Protein-rich beverages were also commonly consumed after a race.

NUTRITION INFORMATION

Eighty seven percent of participants viewed nutrition as being very important in marathons; whereas only three people (0.7%) believed that nutrition is not at all important in marathons.

Approximately 57% of the participants used friends as a source of nutrition information. Other influential sources of nutrition information included magazines (44.7%), websites (32.0%), and coaches (25.8%). Additional information on sources of nutrition information can be found in Table 4.

Participants used a variety of books, magazines, and websites but there were several that were used by many people. Other common sources of nutrition information included experience, trial and error, personal trainers, podcasts, and local running stores. See Table 5 for a specific list of the sources of information provided by the participants.

Many runners read nutrition from various sources fairly frequently (30.5% once a week and 27.8% two to three times per month). However, 16.9% of the 403 participants said they rarely read nutrition articles.

The main reason runners look for nutrition information is to increase energy (72.7% of runners). Runners also look for nutrition information regarding injury prevention (53.6%), improving race time (48.6%), and improving hydration (47.9%). Significantly more women seek nutrition recommendations for weight loss than men [χ^2 (1, n = 403) = 12.18, p = 0.000, phi = 0.18]. Other reasons runners look for nutrition information include promoting general health and in recovering during training or after races.

According to the participants, RDNs and DTRs provide the most reliable source of nutrition information, with 39.1% of participants saying they were "very reliable." Books received the highest rating for "not at all reliable" at 9.1%. More information on the perceived reliability of various sources of nutrition recommendations can be found in Table 6.

DISCUSSION

PRACTICES SURROUNDING NUTRITION

Carbohydrate loading is a commonly used method to maximize glycogen stores before participating in an event that will deplete the stores. Maximizing glycogen stores can delay fatigue and allow runners to maintain their pace for a longer time[11,16,19]. About 45.2% of the participants practiced carbohydrate loading before a long training run and 80.8% did this before a race. For both groups, about 18% of runners use a depletion phase, in which carbohydrate intake is decreased before the "loading" phase. Previously, a depletion phase of three to four days was thought to be necessary before carbohydrate loading for three to four days to maximize glycogen stores[17]. However, subsequent research has shown that a depletion phase is not

necessary, and that only one day of a high carbohydrate diet is necessary to reach near maximal glycogen stores[18]. Therefore, nearly 1 out of 5 marathon runners is practicing carbohydrate techniques that are outdated and not beneficial.

Meals before a run can prevent hunger and provide runners a source of exogenous carbohydrate, which can also help delay fatigue[11,16,20]. Most runners reported consuming a meal two to three hours before a run or race. Pre-run meals should be individualized, but should be timed to allow for adequate gastric emptying[11]. Consuming a meal two to three hours before running would allow for most of the meal to leave the stomach and would be adequate[20]. About a quarter of people consume a meal more than three hours before a run or race. There are benefits and drawbacks to this; this will allow for adequate gastric emptying and glycogen repletion. However, it is recommended to consume a pre-run meal within four hours before a run or race, so the nutrients will be available in the bloodstream to be utilized by muscles[20].

About 80% of runners consume a meal within one hour of completing a training run and about 75% consume a meal within one hour after completing a race. Although consuming adequate carbohydrate is less critical if an athlete is not participating in another event within one to two days compared with an athlete who must compete again the same day, such as triathletes, the 30 minutes directly after exercise is when muscles are most adept to storing glycogen[11,57]. Directly after exercise, GLUT 4 receptors, which allow for the uptake of glucose into the muscles, are at the surface of muscle cells. Therefore, at this time the muscles are able to take up a large amount of glucose[57]. Consuming glucose also raises plasma insulin levels, which help the GLUT 4 receptors remain at the surface to take up more glucose[57].

In addition, consuming adequate carbohydrate after glycogen depleting exercise spares protein[11]. Therefore, the remainder of runners who wait a longer period of time before

consuming a meal may be hampering their recovery and muscular adaptations. Some research suggests that the ingestion of both carbohydrate and protein during the recovery period enhances the rate of glycogen synthesis compared with carbohydrate alone[63]. However, it remains unclear whether this is due to increased calorie intake or the combination of protein and carbohydrate[63]. A commonly consumed recovery drink is chocolate milk, which has both high quality protein and carbohydrates. Studies have found that chocolate milk is an effective recovery drink to help replenish glycogen, repair proteins, and rehydrate[64].

Most people consume complex carbohydrates before a run or a race, including grains, vegetables, and fruit. In addition, many people also consume some source of protein, whether it be meat, fish, or poultry; plant protein; or dairy. After a run or a race, grains, fruit, and animal protein are the main constituents of a meal. This combination of foods would provide simple and complex carbohydrates as well as protein. Simple carbohydrates are important during the recovery period are related to enhanced glycogen synthesis[11]. Complex carbohydrates take longer to digest, and therefore yield glucose at a slower rate. This is also beneficial because it provides a prolonged, steady flow of blood glucose to the recovering muscles.

SOURCE OF NUTRITION INFORMATION AND PERCEIVED CREDIBILITY

As was mentioned, friends, magazines, websites, and coaches were some of the most common sources of nutrition information for marathon runners. Any of these sources have the potential to provide credible nutrition recommendations, but they also have the potential to provide less reliable information that may be a fad or outdated. For example, Runner's World includes a section titled "Ask the Sports Dietitian" and provides a source of nutrition recommendations from a registered dietitian[14]. Trail Runner, another popular magazine for runners, includes nutrition guidance from a variety of different people, including a fitness trainer,

coaches, as well as some from registered dietitians[65]. While experienced runners and coaches may have techniques they believe work for them, this may not be the best or only way to provide nutrition for marathon runners.

A study by the Academy of Nutrition and Dietetics (formerly the American Dietetic Association) found that Americans tend to get general nutrition information from television (67%), magazines (41%), and the Internet (40%)[61]. Although nutrition information from television was not assessed in the current study, findings regarding magazine and Internet sources of nutrition recommendations are similar for this study. In the same study, RDs were rated as "very credible" by 71% of participants, which was higher than any other source including physicians, nurses, or MyPyramid[61]. The current study also found that RDs were perceived to be the most credible source of information, although the percentage was much lower. This may be due to the additional sources of nutrition information for marathon runners such as coaches and friends. Their perceived credibility may be high since these people may have personal experience with nutrition related to marathon running.

Some conclusions can be drawn from how best to reach this population based on the data collected. Considering registered dietitians and coaches are seen as reliable sources of information, RDs and DTRs should reach out to local running coaches, clubs, and organizations to try to gain the respect of these organizations as a reliable source of nutrition recommendations and work directly with the population. In addition, since magazines are a large source of information for marathon runners, RDs and DTRs may be able to write columns or articles for these publications to indirectly provide recommendations to marathon runners. Magazines are often cited as being referenced for nutrition recommendations, but are not seen as reliable as RDs and DTRs. By providing more magazine columns and articles written by RDs and DTRs, this

could enhance the accuracy of the information provided by these publications. Additionally, the Commission on Dietetic Registration (CDR) offers a specialty certification in sports dietetics. RDNs who are Board Certified in Sports Dietetics (CSSD) have demonstrated at least 1,500 hours experience in sports nutrition as an RDN and have passed a sports nutrition certification exam[66]. CSSDs are an extremely reliable source of nutrition recommendations for athletes, as they have the expertise to work with this population.

TYPES OF NUTRITION INFORMATION

The main reason people look for nutrition guidance is to increase their energy. However, nutrition for preventing injury, improving race time, and improving hydration were also commonly sought after recommendations. RDs and DTRs providing nutrition recommendations to this population can use this information to ensure the recommendations they are providing are what the population is interested in learning about.

There are several strengths of this research study. One is the large number of participants, which allowed for relationships to be analyzed between different groups. Also considering that no other research studies were found examining this topic with this population, this study lays the groundwork for further investigation.

This study has some limitations. One limitation is that there is a self-selection bias. Participants in the study may not fully reflect the views and practices of marathon runners as a whole. Another limitation is that over 60% of the sample is women, which may also not reflect the population as a whole. Traditionally more men participate in marathons than women although the difference in gender participation is decreasing[67]. The cross-sectional nature of the study is also a limitation, as this only captures runners' practices at one point in time and practices may change with experience.

There are several changes that could be made to improve the survey used in this study. The main change that could be made is to define terms used, including carbohydrate loading as increasing the amount of carbohydrates for 24 hours before a race. Additionally, for questions regarding intake surrounding runs and races, the term "meal" should be changed to include anything consumed, including meals, snacks, and beverages. In the current survey "meal" was used, which may have influenced participants' responses to only discuss a full meal rather than a recovery drink or snack. For ease of analysis, fewer open-ended questions could be asked as well, specifically in regards to previous participation in races. Instead of the current open-ended format, common race lengths could be listed and participants could check all that apply. Another important change that should be made is to adjust the time frame of post-run and post-race consumption to from within 1 hour to within 30 minutes, as this correlates with current recommendations. Future research should address the previously mentioned changes to the survey utilized in this study. Additionally, future studies should focus on the types and amounts of foods and beverages consumed during training and surrounding races of this population to ascertain whether marathon runners are practicing good nutrition. In addition, running goals and their relation to nutrient intake should be considered.

CONCLUSION

This is the first study to investigate marathon runners' nutrition practices and sources of nutrition recommendations. From this information, RDs and DTRs wishing to provide nutrition recommendations to marathon runners are able to understand some of the main nutrition recommendations sought. These include recommendations to increase energy, prevent injury, improve race time, and improve hydration. When working with female marathon runners, weight loss may be relevant to discuss as well. Additionally, as friends, coaches, and magazines are

large contributors to nutrition information for marathon runners, collaborating with running coaches and organization may allow RDNs and DTRs to reach this population.

This study also identified gaps between recommendations and practice, including using a depletion phase before carbohydrate loading and not consuming a post-run meal within an hour of finishing the run. RDNs and DTRs can use this evidence to tailor their education to correct this misinformation.

Table 1. Characteristics of Sample Population of Marathon Runners

Characteristic	**Total** (n=403)	**Male** (n=156)	**Female** (n=247)
Age, mean ± SD	38.2 ± 10.4	40.4 ± 11.4	36.8 ± 9.5
Previous race, n (%)			
Any length	397 (98.5%)	154 (98.7%)	243 (98.4%)
Marathon (26.2 miles)	276 (68.5%)	112 (71.8%)	136 (55.1%)
Greater than 26.2 miles	26 (6.4%)	17 (10.9%)	9 (3.6%)
Height (in), mean ± SD	67.1 ± 3.6	70.5 ±2.5	65.0 ±2.4
Average weight (lbs), mean ± SD	151.2 ± 30.1	171.5 ± 26.5	138.3 ± 24.7
BMI	23.5 ± 3.6	24.2 ± 3.0	23.0 ± 3.8
Vegetarian/vegan, n (%)	57 (14.1%)	21 (13.5%)	36 (14.6%)

Table 2. Pre- and Post-Training Run Meal Timing and Content

	Pre-Training Meal (n = 403) (%)	Post-Training Meal (n = 403) (%)
TIMING OF MEALS		
Within one hour	131 (32.5)	327 (81.1)
2-3 hours	175 (43.4)	67 (16.6)
> 3 hours	97 (24.1)	9 (2.2)
FOOD GROUPS CONSUMED		
Animal protein	138 (34.2)	274 (68.0)
Plant protein	98 (24.3)	121 (30.0)
Dark green veg	86 (21.3)	136 (33.7)
Starchy veg	66 (16.4)	101 (25.1)
Red-orange veg	45 (11.2)	69 (17.1)
Fruit	255 (63.3)	262 (65.0)
Dairy	111 (27.5)	206 (51.1)
Grains	351 (87.1)	272 (67.5)
BEVERAGES		
Water	360 (89.3)	316 (78.4)
Electrolyte drink	110 (27.3)	201 (49.9)
Protein drink	8 (2.0)	109 (27.0)
Other	70 (17.4)	100 (24.8)

Table 3. Pre- and Post-Race Meal Timing and Content

	Pre-Race Meal (n = 276) (%)	Post-Race Meal (n = 276) (%)
TIMING OF MEALS		
Within one hour	54 (19.6)	212 (76.8)
2-3 hours	151 (54.7)	59 (21.4)
> 3 hours	71 (25.7)	5 (1.8)
FOOD GROUPS CONSUMED		
Animal protein	79 (28.6)	170 (61.6)
Plant protein	62 (22.5)	72 (26.1)
Dark green veg	47 (17.0)	86 (31.2)
Starchy veg	38 (13.8)	72 (26.1)
Red-orange veg	15 (5.4)	47 (17.0)
Fruit	170 (61.6)	207 (75.0)
Dairy	64 (23.2)	143 (51.8)
Grains	248 (89.9)	222 (80.4)
BEVERAGES		
Water	239 (86.6)	231 (83.7)
Electrolyte drink	103 (37.3)	165 (59.8)
Protein drink	10 (3.6)	67 (24.3)
Other	46 (16.7)	69 (25.0)

Table 4. Sources of Nutrition Information Reported by Runners (n=403)

Source	**Number (%)**
Friend	231 (57.3%)
Magazine	180 (44.7%)
Website	129 (32.0%)
Coach	104 (25.8%)
Book	80 (19.9%)
Other	76 (18.9%)
Facebook	32 (7.9%)
Nutritionist, other than RD	26 (6.5%)
RD/DTR	25 (6.2%)
Blog	20 (5.0%)
Twitter	9 (2.2%)
Journal	8 (2.0%)

Table 5. Books, Magazines, Websites, and Other Sources of Nutrition Information

Books	*Marathon: The Ultimate Training Guide* and *Beginning Runner's Guide* by Hal Higdon *Racing Weight* by Fitzgerald *Advanced Marathoning* by Pfitzinger *Runner's World Big Book of Marathon and Half Marathon Training* by Van Allen, Yasso, Burfoot, and Nisevich Bede
Magazines	Runner's World Running Times Trail Runner
Websites	http://www.runnersworld.com http://www.runningtimes.com/running-times http://www.halhigdon.com http://www.active.com
Other	Personal experience Local running store Registered nurse Personal trainer

Table 6. Participants' Perceived Reliability of Sources of Nutrition Information

	Perceived Reliability (%)				
Source	**Not at all reliable**	**Slightly reliable**	**Somewhat reliable**	**More reliable**	**Very reliable**
Friend	4.1	18.5	40.6	26.5	10.3
Coach	4.5	4.2	20.2	46.3	24.7
Book	9.1	5.4	33.3	34.3	17.8
Magazine	4.6	6.4	33.2	42.7	13.1
Website	6.7	8.3	42.9	30.1	11.9
Nutritionist	4.5	6.1	25.5	38.9	25.2
RD/DTR	4.2	3.8	20.2	32.7	39.1

APPENDIX 1

Background Information

- Age:
- Gender:
- Height (feet, inches):
- Average weight during training (in pounds):
- Are you a vegetarian or vegan: yes/no

The following questions refer to the CURRENT marathon you are training for:

- What is your training method for the **current** marathon (check all that apply):
    - I am training alone
    - I am using a book on training for a marathon
    - I am using a smart phone application
    - I am using an online training program
    - I am training with a friend
    - I am training with a club
    - I am training with a coach
- How many days per week do you run?
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6

    - 7
- What is the maximum number of miles you will run in one week during training?
- How many miles will you run in the 7 days before the race?
- Have you previously participated in any running races?
    - Yes
    - No
- If answered yes to question above:
    - Length of previous races (specify miles or km)
    - Number of previous races
    - Personal record for each length of previous race
- Expected race time for **current** marathon:
    - Expected race time
    - Unsure

The following questions refer to dietary and hydration practices while training for the CURRENT marathon:

- Do you carbohydrate load before training runs?
    - Yes
    - No
- If yes to the question above
    - Do you decrease the amount of carbohydrates you consume a few days before increasing the amount you consume?
        - Yes
        - No

- How long before a training run do you consume a meal?
    - Within one hour before
    - 2-3 hours before
    - More than 3 hours before
- Which food groups do you include in a typical meal **before** a training run? (check all that apply)
    - Non-plant based protein (such as eggs, chicken, or beef)
    - Plant-based protein (such as soy, beans, or lentils)
    - Dark green vegetables (such as broccoli, spinach, or romaine lettuce)
    - Starchy vegetables (such as potatoes, corn, or green peas)
    - Red or orange vegetables (such as carrots, sweet potatoes, or squash)
    - Fruit (such as apple, banana, or orange)
    - Dairy (such as milk, yogurt, or cheese)
    - Grains (such as bread, cereal, or pasta)
- What do you drink **before** a training run?
    - Water
    - Electrolyte drink (such as Gatorade or Vitamin Water)
    - Protein drink (such as Muscle Milk or protein shake)
    - Other (please specify)
- How soon **after** a training run do you eat?
    - Within one hour after
    - 2-3 hours after
    - More than 3 hours after

- Which food groups do you include in a typical meal **after** a training run? (check all that apply)
    - Non-plant based protein (such as eggs, chicken, or beef)
    - Plant-based protein (such as soy, beans, or lentils)
    - Dark green vegetables (such as broccoli, spinach, or romaine lettuce)
    - Starchy vegetables (such as potatoes, corn, or green peas)
    - Red or orange vegetables (such as carrots, sweet potatoes, or squash)
    - Fruit (such as apple, banana, or orange)
    - Dairy (such as milk, yogurt, or cheese)
    - Grains (such as bread, cereal, or pasta)
- What do you drink **after** a training run?
    - Water
    - Electrolyte drink (such as Gatorade or Vitamin Water)
    - Protein drink (such as Muscle Milk or protein shake)
    - Other (please specify)
- How do you know how much to drink **after** a training run?
    - Based on how thirsty I am
    - I drink a predetermined amount (such as a bottle or Camelbak)
    - I drink based on the difference in my weight before and after the run
    - Other (please specify)
- Which, if any, of the following have you used while training for the **current** marathon? (check all that apply)
    - Electrolyte drinks (such as Gatorade and Vitamin Water): please specify

    - Protein-rich drinks (such as Muscle Milk or protein powder): please specify
    - Carbohydrate gels (such as Gu, Clif Shot Gel, or Power Gel): please specify
    - Carbohydrate chews (such as Shot Bloks or Energy Blasts): please specify
    - Energy bars (such as Clif bars): please specify
    - Protein bars (such as Pure Protein): please specify
    - Single vitamin or mineral supplement (such as calcium or vitamin B12): please specify
    - Multi-vitamin or mineral supplement (such as Centrum or One-a-Day): please specify
- How often do you use carbohydrate gels during a long training run?
    - Based on mileage: every __ miles
    - Based on time: every __ minutes
    - Other: please specify
    - I do not use carbohydrate gels
- Which of the following best describes you
    - I am training for my first marathon
    - I have previously participated in marathon(s)

The following questions refer to dietary and hydration practices during PREVIOUS marathons:

- Do you carbohydrate load before a race?
    - Yes
    - No
- If yes to the question above

    - Do you decrease the amount of carbohydrates you consume a few days before increasing the amount you consume?
        - Yes
        - No

- How long before a race do you consume a meal?
    - Within one hour before
    - 2-3 hours before
    - More than 3 hours before
- Which food groups do you include in a typical meal **before** a race? (check all that apply)
    - Non-plant based protein (such as eggs, chicken, or beef)
    - Plant-based protein (such as soy, beans, or lentils)
    - Dark green vegetables (such as broccoli, spinach, or romaine lettuce)
    - Starchy vegetables (such as potatoes, corn, or green peas)
    - Red or orange vegetables (such as carrots, sweet potatoes, or squash)
    - Fruit (such as apple, banana, or orange)
    - Dairy (such as milk, yogurt, or cheese)
    - Grains (such as bread, cereal, or pasta)
- What do you drink **before** a race?
    - Water
    - Electrolyte drink (such as Gatorade or Vitamin Water)
    - Protein drink (such as Muscle Milk or protein shake)
    - Other (please specify)
- How soon **after** a race do you eat?

    - Within one hour after
    - 2-3 hours after
    - More than 3 hours after
- Which food groups do you include in a typical meal **after** a race? (check all that apply)
    - Non-plant based protein (such as eggs, chicken, or beef)
    - Plant-based protein (such as soy, beans, or lentils)
    - Dark green vegetables (such as broccoli, spinach, or romaine lettuce)
    - Starchy vegetables (such as potatoes, corn, or green peas)
    - Red or orange vegetables (such as carrots, sweet potatoes, or squash)
    - Fruit (such as apple, banana, or orange)
    - Dairy (such as milk, yogurt, or cheese)
    - Grains (such as bread, cereal, or pasta)
- What do you drink **after** a race?
    - Water
    - Electrolyte drink (such as Gatorade or Vitamin Water)
    - Protein drink (such as Muscle Milk or protein shake)
    - Other (please specify)
- How do you know how much to drink **after** a race?
    - Based on how thirsty I am
    - I drink a predetermined amount (such as a bottle or Camelbak)
    - I drink based on the difference in my weight before and after the run
    - Other (please specify)
- How often do you use carbohydrate gels during a race?

    - Based on mileage: every __ miles
    - Based on time: every __ minutes
    - Other: please specify
    - I do not use carbohydrate gels
- How many total carbohydrate gels do you consume during a typical marathon?
    - I do not use carbohydrate gels
    - 1-3
    - 4-6
    - 7-9
    - 10-12
    - 13-15
    - 16-18
    - More than 18
- How often do you use carbohydrate chews during a race?
    - Based on mileage: every __ miles
    - Based on time: every __ minutes
    - Other: please specify
    - I do not use carbohydrate chews
- How many total carbohydrate chews do you consume during a typical marathon?
    - I do not use carbohydrate chews
    - 1-5
    - 6-10
    - 11-15

- 16-20
- 21-25
- 26-30
- More than 30

The following questions refer to sources of nutrition information you use:

- How important is nutrition to marathon performance?
  - Not at all important
  - Somewhat important
  - Very important
  - Don't know
- Which of the following source(s) do you receive and use nutrition information from? (check all that apply)
  - Friend
  - Coach
  - Book: please specify
  - Magazine: please specify
  - Peer reviewed journal (such as Journal of the American Medical Association): please specify
  - Website: please specify
  - Twitter: please specify
  - Facebook: please specify
  - Blog: please specify
  - Nutritionist, other than a Registered Dietitian

    - Registered Dietitian or Dietetic Technician, Registered
    - Other: please specify

- How often do you read nutrition articles?
    - Once a week
    - 2-3 times a month
    - Once a month
    - Once every 3 months
    - Rarely
    - Never
- What types of recommendations do you look for in nutrition articles? (check all that apply)
    - Improve race time
    - Improve hydration
    - Prevent injury
    - Lose weight
    - Gain weight
    - Increase energy
    - Other
- Rank each of the following sources of nutrition information based on their ability for accurate and helpful information (1=not at all reliable; 2=slightly reliable; 3=somewhat reliable; 4=more reliable; 5=very reliable)
    - Friend
    - Coach

- Book: please specify
- Magazine: please specify
- Website: please specify
- Nutritionist, other than a Registered Dietitian
- Registered Dietitian or Dietetic Technician, Registered
- Other: please specify

If you have comments or suggestions regarding the survey, please describe them below.

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Education

Syracuse University, Syracuse, NY
M.S. Nutrition Science and Dietetics, anticipated completion May 2014

University of Toledo, Toledo, OH
B.S., *summa cum laude*, Exercise Science, May 2012

Honors and Awards

President's List, University of Toledo	12/2008, 05/2011-05/2012
Camp Adventure Child & Youth Services Achievement Award	04/2011
Dean's List, University of Toledo	05/2009 – 12/2010

Work and Volunteer Experience

Crouse Hospital; care coordination assistant	01/2014-present
Syracuse University; Teaching Assistant	08/2012-present
Crouse Hospital; care coordination volunteer	08/2013-12/2013
Shadow Valley Tennis Club; Customer Service Representative and Tennis Aide	08/2011-07/2012
Turin Tennis & Swim Club; Head Lifeguard, Swim and Tennis Instructor	05/2011-08/2011
Camp Adventure Youth Services; Camp Counselor, Swim Instructor, Lifeguard	06/2009-08/2010

Presentations and Publications

Gluten-free, Dairy-free, and Vegetarian Diets in Pregnancy; *Peri-FACTS Academy*	04/2014
Syracuse Crunch AHL Hockey	01/2013, 11/2013
Syracuse Behavioral Health	04/2013
Syracuse Surge Girls Field Hockey	03/2013

Professional Organizations

Academy of Nutrition and Dietetics; student member
Collegiate and Professional Sports Dietitians Association; student member
Nutrition Education and Promotion Association; member