Recommendations for thon Runners

By: Alison Osowski

Introduction

Marathon running is common all around the world. There are many kinds of marathons, but running marathons are the most common. A full running marathon consists of running 26.2 miles along a course, often through a city or other trail. The average time for a male runner in 2013 was 4 hours 16 minutes (9:46/mile pace) compared to the average for females at 4 hours 41 minutes (10:43/mile pace) (Running USA, 2014). The men's record for the fastest marathon ran to date was completed at the 2011 Boston Marathon by Geoffrey Mutai with a time of 2:03:02 (roughly 4.7 minutes/mile), whereas the women's record for the fastest marathon is 2:17:42 at the 2005 London Marathon (Running USA, 2014). Many athletes also run half marathons, which consist of 13.1 miles and are usually along a shorter version of the same course used for the full marathon. There are usually hundreds of people that participate in a marathon at one time. According to Running USA, the ten largest marathons in the United States are:

1. **ING New York City Marathon**, New York City, New York (43,660 finishers, average)
2. **Bank of America Chicago Marathon**, Chicago, Illinois (33,701 finishers, average)
3. **Boston Marathon**, Boston, Massachusetts (22,843 finishers, average)
4. **Marine Corps Marathon**, Washington, D.C. (21,405 finishers, average)
5. **Honolulu Marathon**, Honolulu, Hawaii (20,323 finishers, average)
6. **Walt Disney World Marathon**, Orlando, Florida (14,948 finishers average)
7. **Los Angeles Marathon**, Los Angeles, California (14,125 finishers, average)
8. **Rock 'n' Roll San Diego Marathon**, San Diego California (13,391 finishers, average)
9. **Medtronic Twin Cities Marathon**, Minneapolis, Minnesota (8,474 finishers, average)
10. **Portland Marathon**, Portland, Oregon (8,166 finishers, average)

To competitively run 26.2 miles, the athlete must train vigorously for months before the event, along with maintaining a healthy and specific diet to meet the high energy needs of this type of

nded part of the athlete's diet.

Literature Review

Previous literature has proven that carbohydrates are the most crucial nutrient of endurance athletes. Runners commonly use carbohydrate gels and other supplements during the event to help replenish carbohydrate levels. Phillips et al. (2012) conducted a study to test the efficiency of these carbohydrate gels. The study tested the effects of these carbohydrate gels on endurance capacity and sprint performance of team of 26 athletes. The results of the study showed that the consumption of a carbohydrate gel before and during an event significantly improves the endurance capacity of athletes, but had little beneficial effect on sprint performance. Stellingwerff (2012) conducted another study that had shown results similar to this. Three elite marathon runners were tested and each participant ran two marathons: one supplementing with plain water throughout the event and the other supplementing with carbohydrate containing sports beverage. The results of this study show that, in each participant, the race using the carbohydrate-containing sports drink resulted in a shorter finishing time compared to the race supplemented with just water. Dempster et al. (2013) conducted a study that showed that carbohydrates were the most important nutrient when training for an endurance event. A male ultra-endurance runner followed general guidelines for a single bout endurance event which are 10 grams carbohydrates/kg body mass/day and 1.2-1.6grams protein/kg body mass/day. The conclusion was that he had adequate levels of carbohydrates and protein to provide the daily energy needed and no loss of body mass was indicated. One additional study was conducted by Henson et al (2004) to identify the influence of carbohydrate consumption and age on lymphocyte function immediately after finishing a marathon. Each runner was assigned either the placebo or the carbohydrate containing beverage. The results showed that post-race lactate levels were lower in the placebo group compared to the carbohydrate group but finishing times between the two groups did not differ. The results also indicated that the placebo group showed lower plasma glucose and insulin levels.

Ivy et al. conducted a study which analyzed the consumption of a carbohydrate-protein supplement post-exercise on muscle glycogen synthesis rates compared to only consuming carbohydrate containing supplements. In this study, 7 participants cycled for 2.5 hours, and each was given a carbohydrate containing supplement. After a period of time, the participants cycled again for

supplement or a high-carbohydrate containing supplement or a lower-carbohydrate containing supplement. The results showed that the addition of protein post-exercise increased muscle glycogen synthesis rates and the supplements with the two different levels of carbohydrates did not affect glycogen synthesis rates.

Before the Event

One Week Before the Event

Carbohydrates are the most important nutrient for marathon athletes to consume when preparing for a marathon. Because the skeletal muscles are fuelled mainly by **glucose** derived from carbohydrates, it is important to adequately build up muscle stores of glycogen to promote a decrease in fatigue during the race. Figure 1 shows the molecular structure of one molecule of glucose. In Stellingwerff's "Case Study: Nutrition and Training Periodization in Three Elite Marathon Runners", it was proven that a diet consisting of an increase from 45% to 65% of the calories consumed daily came directly from carbohydrates. This promotes carbohydrate storing (2012).

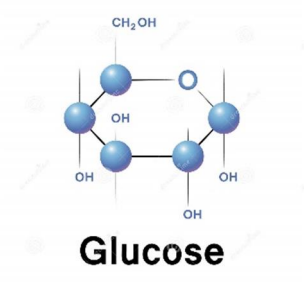

Figure 1: Glucose molecule

One Day Before the Event

The day before the event is the most crucial time period to prepare the body for the marathon ahead. The day directly before the event is the day where carbohydrate intake is extremely important to prevent the "hitting the wall" sensation that often happens and is the result of overwhelming fatigue.

A common and useful preparation strategy is known as **carbohydrate loading**. Carbohydrate loading is the super compensating of muscle glycogen stores in preparation for prolonged exercise. Each gram of carbohydrate provides four calories of energy for the athlete. According to the Mayo Clinic, effective carbohydrate loading consists of 6-10 grams of carbohydrates per kilogram of body weight (2012). Carbohydrate loading has not been associated with an increase in overall running speed, but instead, with an increased ability to maintain running pace throughout the event (Burke, 2007). Many runners have experienced a sensation commonly known as "hitting the wall." This happens when the athlete

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causing the athlete to run out of energy. Carbohydrate loading helps prolong this glucose depletion leaving the athlete energized for a longer period of time.

Male and female athletes mostly benefit from carbohydrate loading in similar ways. Previous claims stated that female athletes fail to super-compensate muscle glycogen stores this is believed to be caused by the smaller amounts of carbohydrate and restricted energy intakes of females. But when females are able to achieve an increase in glycogen storage, they see similar benefits as males. The menstrual status of females also effects glycogen storage with greater storage occurring during the luteal phase rather than the follicular phase (Burke, 2007). The athlete should avoid the consumption of fiber and fats before the marathon because of the issues it may cause with digestion (Moran, Dzledzic, & Cox, 2011).

The following is an example of a meal plan that a 150 pound athlete could following for one day of carbohydrate loading before the event.

BREAKFAST	Carbs	Protein	Fat	Calories
Banana	27 g	1.3 g	0.4 g	105
3/4 cup Rolled Oats	41 g	12g	6g	225
1 Whole wheat bagel	52g	11g	1.5g	260
2 tablespoons peanut butter	6 g	8 g	16 g	188
12 oz. chocolate milk	38 g	12 g	13 g	312
Total	164 grams	44 grams	37 grams	1,090

LUNCH	Carbs	Protein	Fat	Calories
2 cups Pasta	130 g	25 g	4 g	663
¾ cup alfredo sauce	9 g	3 g	30 g	330
20 oz Gatorade	40 g	0 g	0 g	160
Total	178 g	28 g	34 g	1,152

DINNER	Carbs	Protein	Fat	Calories
1 potato	27 g	2.5	0 g	115
6 oz rib eye steak	0	45 g	28 g	450
2 slices garlic bread	36 g	6 g	14 g	300
20 oz Gatorade	40 g	0 g	0 g	160
Total	102 g	54 g	43 g	1,024

Now, let us prove that this meal plan provide sufficient amount of carbohydrates for this athlete.

Kilograms= pounds÷ 2.2

Kilograms= 150 pounds ÷ 2.2

Kilograms= **68.2**

Total carbohydrates supplied from this meal

From these calculations, it is proven that this athlete will be provided with enough carbohydrates to receive the benefits of carbohydrate loading. Because 6.5 grams of carbohydrates per kilogram is on the lower end of the recommendation, this athlete could consume an even higher level of carbohydrates if they wished.

What happens if the runner has Celiac's Disease and cannot consume gluten? **Celiac's Disease** is an autoimmune disorder affecting absorption from the intestine as villi inflammation and flattening occur. Because gluten is one of the main forms of carbohydrates, other sources must be found. Common sources of carbohydrates for those with this intolerance could include gluten-free whole grain cereal and breads, gluten-free pastas, fruits, brown rice, yogurt, fruit juices, and gluten free granola bars (Black, Skidmore, & Brown, 2012).

Morning Before the Event

The morning before the marathon, the athlete must again consume a mixture of carbohydrates. A study by Stellingwerff et al. (2013) proved that the consumption of a mixture of glucose and fructose can result in a 20-40% increase in exogenous carbohydrate oxidation during exercise as compared with a single carbohydrate source, which means that carbohydrate stores are utilized more efficiently. The athlete should also stay adequately hydrated the hours before the event. Drinking 8 to 16 ounces of water or a sports drink 1-2 hours before the event is beneficial (Dempster, Britton, Murray & Costa, 2013).

During the Event

During the marathon, it is crucial to remain hydrated and to prevent glucose levels from sinking too low, known as **hypoglycemia**. This can be avoided by consuming carbohydrate sources during the event. Consuming carbohydrates will replenish glucose levels in the skeletal muscles which will help prolong the onset of fatigue, causing an improvement of exercise performance by allowing the runner to maintain their running pace longer. The positive effect of the consumption of carbohydrates during endurance is proven by a study done by Phillips, et al. who conducted a study on teen athletes. The results of this study supported that concept that carbohydrate supplementing improved endurance capacity but the carbohydrate supplements did not have an effect on sprint performance (2012). This supports the idea that carbohydrate supplementing during exercise prolongs fatigue but does not cause the athlete to be faster or decrease finishing times. Stellingwerff (2012) conducted a study on three

supplemented by plain water and the other supplemented with a carbohydrate containing sports drink. In each runner, the race that was supplemented by the sports drink resulted in a shorter finishing time compared to the marathon fueled by plain water.

Many options are available for athletes to provide this carbohydrate source during exercise. The most common supplements used during the marathon include sports drinks and energy gels and gummies. Each of these supplements should be introduced to the body before the event and should be used when training so as to let the body adapt and become familiar with the product.

The common sports drink, Gatorade, contains 12 grams of carbohydrates per 8 fluid ounces. Sports drinks are beneficial because they provide carbohydrates and help rehydrate the runner, but they are also not as energy-dense as gels and gummies and may be too sweet to consume enough during the race to consume the needed carbohydrates from it.

Figure 2 shows an example of an aid station in the Chicago Marathon. Gatorade is a very common sports drink that is used to supplement runners during marathons.

	Carbohydrate	Calories
PowerAde 8 oz	14 grams	50
Gatorade 8 oz	16 grams	63

Figure 3 compares the common carbohydrate-containing sports drinks and their carbohydrate and caloric levels.

Gels and gummies contains anywhere between 23-28 grams of carbohydrate per ounce. These are much more energy dense and the use of gels and gummies may allow the runner to more easily reach the necessary levels of carbohydrate consumption during the event. Gels and gummies should always be consumed with a small amount of water to allow for faster digestion and absorption. These should never be consumed in combination with a sports drink because of the risk of ingesting too much sugar at once. Even though these sources have the highest carbohydrate levels, runners find it harder to stomach solids during the race.

Energy Gel	Calories	Carbs (g)
Accel Gel	76	15
Carb-BOOM!	76	19
E-Gel	77	20
Hammer Gel	77	19
Honeystinger	92	23
Power Gel	74	20
Vega Sport	63	13
Lava Gel	83	21
Gu	88	23
Reload	78	19

Figure 4 compares common energy gels and their calorie and carbohydrate levels. The average carbohydrate levels

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The level of carbohydrates needed during the event depends on the duration of the event, the intensity of the exercise, and the body weight of the athlete. Athletes who perform at intensities that are lower will have lower carbohydrate oxidation rates and will need lower carbohydrate intake levels. Figure 3 presents the guidelines of the amount of carbohydrates and types of carbohydrates that should be consumed based on the duration of the exercise.

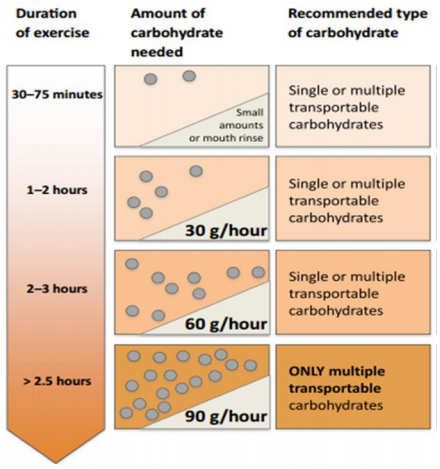

Figure 3 shows the recommended levels of carbohydrate intake during an endurance event depending on the duration of the exercise.

After the Event

After the marathon, the athlete must replenish the muscles and their glycogen stores because the glycogen levels were extremely depleted during the marathon to fuel the body's extreme energy needs. Resting muscle glycogen stores range from 500 to 600 mmol/kg body weight and will decrease greatly during prolonged endurance exercise. According to Beelen, Burke, Gibala, and J.C van Loon, glycogen stores can decline by up to 50-75% during 3 hours of cycling at 70% VO_{2max}. The consumption of 1.2 grams of carbohydrates per kilogram of body weight is the ideal amount of carbohydrates to consume after an endurance event. The consumption of protein at a ratio of 1:3 with carbohydrates post exercise increases the muscle's ability to replenish glycogen stores (Ivy et al., 2002) . In other words, the consumption of small amounts of protein, 0.4 grams per kilogram of body weight, in combination with carbohydrates is the ideal post workout nutrition.

Post exercise muscle glycogen synthesis occurs in two different phases. The first phase of glycogen synthesis, is independent of circulating insulin and lasts about 30-60 minutes after the completion of exercise. During this phase, glycogen synthesis rates are high (30-45 mmol per kilogram), but decrease rapidly when no carbohydrates are ingested. Studies have showed that this phase only occurs when post exercise muscle glycogen levels are reduced to under 150-220 mmol per kilogram (2010). The consumption of carbohydrates during this phase is crucial because the glycogen-synthesis rates are the highest causing the muscle glycogen stores to be replenished more adequately. The second phase is known as the insulin-dependent

is rate cogen levels can be restored during this phase, but more carbohydrates must be consumed for the muscles to be able to take up as much glycogen as they would have during the first phase because glycogen synthesis rates are lower.

Post Marathon Meal Example

- 12 fluid ounces 2% chocolate milk
- 1 medium banana
- ½ whole wheat bagel with 2 tablespoons of peanut butter

Total grams carbohydrates: 105 g.

For a 150 pound person, 105 grams is a sufficient level of carbohydrates to replenish muscle glycogen stores following an endurance exercise. The recommended amount of carbohydrate consumption is 82 grams.

Kilograms= 150 pounds ÷2.2
Kilograms=68.2
Carbohydrate grams=68.2 kilograms÷1.2 grams
Carbohydrate grams=82 grams

Once the level of 1.2 grams per kilogram of body weight is reached, muscle glycogen synthesis rates will not increase; the time frame in which the carbohydrate is consumed affects the glycogen synthesis rate. Studies have shown that the consumption of small amounts of protein in combination with the carbohydrates causes an increase in glycogen synthesis. Figure 5 shows the difference in glycogen synthesis rates when consuming protein-containing supplements and supplements with different levels of carbohydrates.

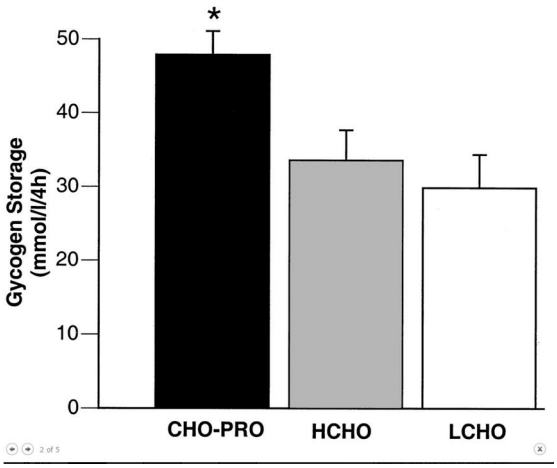

Figure 5 compares how the consumption of a protein and carbohydrate-containing supplement (CHO-PRO), a high carbohydrate containing supplement (HCHO), and a low carbohydrate containing supplement (LCHO) all effect glycogen synthesis per 4 hours. Source: Ivy et al.

Conclusion

In conclusion, carbohydrates are the most essential nutrient concerning endurance exercise. Because carbohydrates are the skeletal muscles' main source of fuel, glycogen stores in the muscles must always be at adequate levels to provide the athlete with the needed energy to run the 26.2 miles of a marathon. Carbohydrate loading is a very common practice among endurance athletes to super compensate the muscle glycogen levels and to ensure that the muscles have access to adequate amounts

practiced by runners. The consumption of carbohydrate containing energy drinks, gels, and gummies during the race replenish carbohydrate levels and, in turn, providing the muscles with more glycogen. Most marathons provide aid stations throughout the race to provide the runners with these supplements. After the race, it is crucial that the runner consume 1.2 grams of carbohydrates per kilogram of body weight to replenish muscle glycogen stores. Because consuming a small level of protein along with the carbohydrates after exercise will increase the muscles' glycogen synthesis rates, 0.4 grams of protein per kilogram of body weight is recommended combined with the carbohydrates. As mentioned before, carbohydrates are the most important nutrient an endurance athlete, like a marathon runner, can consume.

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