

# Effects of Carbohydrate Loading on High Performance Athletics

Ali Mueller, Amelia Reek, Josh Schantzen



**C**arbohydrate loading is a dietary practice used by elite athletes use in order to aid in event performance by supplying adequate energy sources through skeletal muscle glycogen content. Carbohydrate loading is a type of diet where foods high in carbohydrates are eaten a few days prior to or right before an event; this is believed to help aid and provide energy during long-term endurance events. Carbohydrates are a main fuel source for the body; loading up on carbohydrates is believed to help store large amounts of energy and is used to help replenish and load muscle glycogen content. It is common for professional athletes as well as novists to carbohydrate load the day or a few days prior to an athletic event. Muscle glycogen is the main fuel muscles use in order to perform work on a day-to-day basis. Carbohydrates are broken down by the body and turned into glycogen; which is stored in muscles. Carbohydrate loading is believed to place high amounts of glycogen into muscles in turn aiding in physical performance and long-term endurance.

## Carbohydrate Rich Foods

Slice of bread	15g
Piece of lasagna	19g
Apple	25g
Banana	27g
Cup of oatmeal	30g
English muffin	30g
Slice of pizza	36g
Bagel	48g
Large baked potato	60g

**Spotlight on Carbohydrate Loading from a Sports Professional**

<http://www.youtube.com/watch?v=heQ5eukh8t8>

Research has shown that carbohydrate loading helps to raise muscle glycogen content. It is believed that carbohydrate loading the day or night prior to a long endurance will provide adequate and extra energy to muscles. Although Carbohydrate loading is popular practice; many are unaware of the process and benefits. Carbohydrates are a main fuel source of the body and help in overall muscle use. Glycogen is the main energy source used by muscles and provides energy during exercise and physical activity.

A vast number of studies have been conducted on carbohydrate loading; through this research it has been confirmed that when done properly, carbohydrate loading does work. Carbohydrate loading used to increase or elevate muscle glycogen content higher than normally has been shown to increase energy during endurance events. A study conducted in 1996 by Akerman, C et al; examined Swedish hockey players; the players were randomly split into two groups. The athletes were either given a high carbohydrate diet or a regular mixed foods diet. The players who consumed the carbohydrate rich diet showed improvement in overall speed, distance, and time skating compared to that of the players on a regular diet.

In another study done to test the effect of carbohydrate loading; mountain bike participants were randomly selected into groups where one



group was given a high carbohydrate diet before a given race and the other a low carbohydrate diet. The high carbohydrate diet consisted of 3 grams of carbohydrate per kilogram of body weight while the low carbohydrate diet consisted of 1 carbohydrate per kilogram of body weight. The researchers found that initially the competitors consuming the lower carbohydrate diet performance appeared to have more energy in the first lap around the course but by lap four the high carbohydrate diet racers were ahead. They found that the high carbohydrate diet racers had a 3% increase in performance compared to the lower carbohydrate diet racers. A 3% increase may not be significant in short-term races or sprint races, however in endurance or longer lapped races it may help increase in performance and overall energy. In most studies muscle biopsies were performed on the participants before and after their experiment and sometimes even during the trial.

Although some studies showed no increase in overall performance; most of these biopsies showed and increase in muscle glycogen content after the experiment was conducted.

A third study conducted by Hatfield, D.L. et al; examined the effects of carbohydrate loading on repetitive jump squat performance. Researchers found no increase in performance level when eight healthy men were given a high carbohydrate diet and a low carbohydrate diet prior to performing the test.

Other outliers or factors can affect ones physical performance, these include already having adequate glycogen content, overall physical performance ability (such as being physically trained or untrained) and overall health. The third study did not specify if the eight men have been conditioned or are regularly physically active. Also mental factors can inhibit or increase performance aside from muscle glycogen content. If one believes they are going to perform better and or worse after increasing carbohydrate intake, there is a possibility that it may skew the data. Showing an increase muscle glycogen content after carbohydrate loading helps to determine that carbohydrates will aid in the recovery and replenishment of muscle glycogen content after a high intensity athletic event.

### ***Carbohydrates and Carbohydrate Loading:***

According to Webster's Dictionary, the definition of a carbohydrate is, "any of a large group of organic compounds occurring in foods and living tissues and including sugars, starch, and cellulose. They contain hydrogen and oxygen in the same ratio as water (2:1) and typically can be broken down to release energy in the animal body." More specifically, carbohydrate loading or sometimes referred to as carb-loading or carbo-loading can be defined by Webster's dictionary as, "a strategy used by endurance athletes, such as marathon runners, to maximize the storage of glycogen (or energy) in the muscles". Most high endurance athletes use carbohydrate loading as a nutrition regimen a few days prior to the event; because carbohydrate loading is known to produce an increase in stored muscle glycogen; which is known to prolong exercise, along with improve long-term performance. Although this theory has been researched extensively, the gender difference does make an impact on the muscle glycogen storage in men and women. Over time, men seem to increase their muscle glycogen storage much higher than women, whereas women increase their muscle glycogen about 13% when eating a high CHO diet for six days or more (Chen, 2008).

## ***Carbohydrate Loading effects on long distance Endurance Exercise:***

When gearing up to run a marathon (26.2 miles) a runner's number one goal is to stay energized as long as possible, along with prolonging fatigue as long as possible. Carbohydrate loading before a race along with intermittent intake of carbohydrates between training runs has been shown to promote restoration of muscle glycogen during the endurance run along with help the runner to train harder, and recover optimally after long runs (Burke, 2007). Of course with any exercise regimen, the exercise intensity and duration plays a key role in the carbohydrates that are used during that exercise.

With carbohydrate loading, in order to get the most optimal amount of stored muscle glycogen, the runs should be moderate intensity lasting ninety minutes or more. This is also the optimal intensity and duration to prolong muscle fatigue by about twenty percent (Hawley 2012). For similarity and balance with training to the race, it is most beneficial to eat 7-10grams of carbohydrate per kilogram body weight the night before the race and long distance training runs. As well as proper hydration and replenishment of electrolytes, it is also recommended to eat about 55% of the diet carbohydrate, and the night before race day it is recommended to eat about 70% of the diet carbohydrates.

	90kg (198 pounds)		
	4g/kg	7g/kg	10g/kg
<b>Breakfast</b>	1 cup Special K (22g) 1 cup Milk (11.5g)	2 cups Special K (44g) 1 cup Milk (11.5) 1 medium Banana (27g)	3 pancakes (135g) 2 cups Special K (44g) 1 cup Milk (11.5) 1 medium Banana (27g)
<b>Snack</b>	1 cup Yogurt (46g)	1 cup Yogurt (46g)	1 cup Yogurt (46g) 1 large Blueberry Muffin (66g) 1 medium Banana (27g)
<b>Lunch</b>	1 cup Pasta (40g) 1 slice Whole Wheat Toast (13g) 500 ml Sports drink (18g)	2 cups Pasta (80g) 1 slice Whole Wheat Toast (13g) 1000 ml Sports drink (36g)	2 cups Pasta (80g) 1 slice Whole Wheat Toast (13g) 1000 ml Sports drink (36g)
<b>Snack</b>	1 medium Apple (19g) 1 cup Yogurt (46g)	2 cup Yogurt (92g) 1 large Blueberry Muffin (66g)	2 cup Yogurt (92g) 1 large Blueberry Muffin (66g)
<b>Dinner</b>	2 cups Pasta (80g) 1 slice Whole Wheat Toast (13g) 500 ml Sports Drink (18g)	2 cups Pasta (80g) 2 slices Whole Wheat Toast (26g) 1000 ml sports Drink (36g)	3 cups Pasta (120g) 2 slices Whole Wheat Toast (26g) 1000 ml sports Drink (36g)
<b>Snack</b>	1 medium Banana (27g) 1 cup Milk (11.5)	1 cup Yogurt (46g) 1 medium Banana (27g)	1 cup Yogurt (46g) 1 medium Banana (27g)
<b>Total</b>	365 (out of 360g)	630.5 (out of 630g)	898.5 (out of 900g)

The table.1 shown above is an example of a normal carbohydrate loaded meal, which a "healthy" college age male might choose to eat before a high endurance athletic event.

### *Interview with a Marathon Runner*

Leah Mueller, who has experience running multiple full marathons, was recently interviewed regarding running and carbohydrate intake. She started running when she was 22 years old, now 26; she has run and finished a total of 5 full marathons. She has completed Grandma's marathon in June of 2011, 2012, 2013, and 2014 and most recently the full Madison Marathon the first weekend in November 2014. She has a personal best of finishing in 4 hours and 15 minutes, and usually follows a 5-6 month extensive training regimen. A series of questions were asked with regards to her diet and training during the training months and up to the few hours before the race.



**Question:** Leah how did you start running marathons?

**Answer:** “I have always played sports all the way through high school including varsity volleyball for four years, and then I was on the rowing team all through college at St. Cloud State, and I wanted to take on a new hobby and challenge for myself that would get me in shape and push myself to do something I have never done before.”

**Question:** What changes did you make to your diet when you started running, specifically after long distance runs (10 miles or more)?

**Answer:** “I wouldn't say it was a drastic change, but I ate a lot smaller meals more frequently throughout the day, to not only stay full, but keep my metabolism up. I ate a mix between carbohydrates and protein about half and half with each meal. I also drank a lot more water, and would drink a PowerAde after the run to replenish thirst and electrolytes.”

**Question:** What was your meal the night before the race?

**Answer:** “Whole wheat spaghetti with meat sauce, Caesar salad, a large glass of milk, and actually a few chocolate chip cookies (very weird I know). The portions weren't drastically larger, but I definitely ate until I was full.

A lot of people think you should eat a lot more than you actually should, it's not about over eating, it is about listening to your body and knowing what foods make you feel good and what ones don't. Everyone is different, and that is why it is good to test out what you eat before the race before the night before, to know what makes you feel full longest, along with not feeling ill, and helping you run your best race possible."

**Question:** What did you eat the morning before the race (breakfast)?

**Answer:** "I usually get up about 3 hours before the race (4:30am for Grandma's) when the race started at about (7:30). I would eat one medium bowl of Almond Vanilla Special K cereal, and two bananas along with lots of water and a full 20oz PowerAde. I would bring protein granola bars (two or three) and eat them on the bus, along with a half of a bar 45 minutes before the start of the race while stretching. I am drinking a plentiful amount water to hydrate before the race."

**Question:** Did you eat anything while running the race?

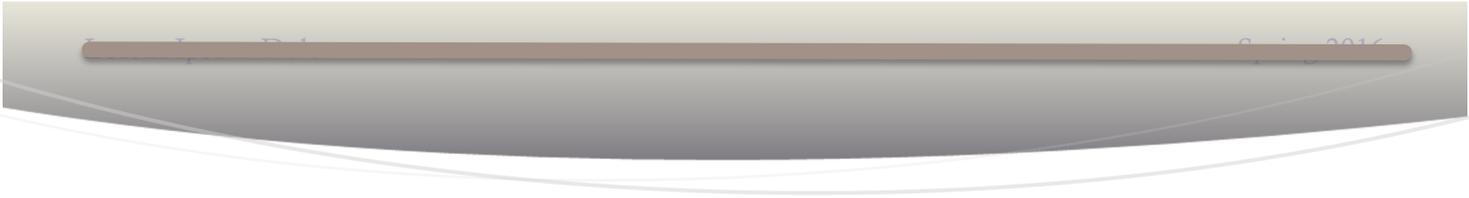
**Answer:** "I mostly drank fluids during the race, I switched off PowerAde and water at every hydration station, but I prefer water mostly.

From miles 20-26 on the Grandma's Marathon

strawberries and oranges, and I took two or three of these to get a boost of energy at the very end. When they handed out the "goos" I never preferred eating them, but if I were starting to hit a wall towards the end, I would pop some of it in my mouth for extra energy. Otherwise I never wore a hydration belt, or had food carrying with me along with way. I just listened to my body to decide what I needed to keep going."

**Question:** After the race, do you think your diet affected how you preformed? Would you change anything for your next race?

**Answer:** "I try to stick to the same diet with the amount of carbohydrate loading the night before the race and the morning before the race. I feel like it has worked for me, and I really like the way I feel when running. I rarely experience cramping, or stomach pains, and I like how the meals make me feel. If I could change one thing I would like to try and incorporate the energy gels into my next training regimen because with the more I have learned about running marathons, other people have had positive experiences running with them (the gels). I would definitely use them while training to see how my body reacts positive or negatively before I run my next race. There are so many opinions in the runner's world with diet and training, and I believe it is what works best for you and what your body responds to the foods you eat that make you feel the way they do."



She went on to say how she discovered running by herself, by listening to her own body. She said that a lot of her diet she used during athletics in high school and college transferred over to what she used while training for her races. She believes solely on what works personally for your body, and everyone is different, so it is best to listen to what you feel like during and after long distance runs to experience the best results for the race. She says running marathons are her new addiction, and it is the most motivating experience she has had in her entire life. Many elite runners would agree that diet is crucial to performance; carbohydrate loading provides an increase in stored muscle glycogen; which is known to prolong exercise.

Åkermark, C., Jacobs, I., Rasmusson, M., & Karlsson, J. (1996). Diet and muscle glycogen concentration in relation to physical performance in Swedish elite ice hockey players. *International Journal of Sport Nutrition and Exercise Metabolism*, 6(3), 272-284. Retrieved from SCOPUS database.

Burke, L. M. (2007). Nutrition strategies for the marathon: Fuel for training and racing. *Sports Medicine*, 37(4-5), 344-347. Retrieved from SCOPUS database.

Chen, Y., Wong, S. H. S., Xu, X., Hao, X., Wong, C. K., & Lam, C. W. (2008). Effect of CHO loading patterns on running performance. *International Journal of Sports Medicine*, 29(7), 598-606. Retrieved from SCOPUS database.

Carbohydrate." *Merriam-Webster*. Merriam-Webster, n.d. Web. 10 Oct. 2014.

Hatfield, D. L., Kraemer, W. J., Volek, J. S., Rubin, M. R., Grebien, B., Gómez, A.L., et al. (2006). The effects of carbohydrate loading on repetitive jump squat power performance. *Journal of Strength and Conditioning Research*, 20(1), 167-171. Retrieved from SCOPUS database.

Hawley, J. A., Schabert, E. J., Noakes, T. D., & Dennis, S. C. (1997). Carbohydrate-loading and exercise performance. *Sports Medicine*, 24(2), 73-81.