

There is little doubt that carbohydrates play a key role in athletic performance. Carbohydrate, in the form of glucose, fuels muscles, the brain and nerves before, during and after exercise. Depending on the food source, carbohydrate ingestion can affect the body in different ways, creating responses that can either hinder or help athletic performance.

We asked Melinda M. Manore, Ph.D., R.D, FACSM, the chair of the Department of Nutrition and Food Management at Oregon State University, to examine the topic of the glycemic response to carbohydrate ingestion and its effect on athletic performance.

We hope you find this information useful.



Bob Murray, Ph.D., FACSM
Director, Gatorade Sports Science Institute



USING GLYCEMIC INDEX TO IMPROVE ATHLETIC PERFORMANCE

Melinda M. Manore, Ph.D., R.D., FACSM

- Glycemic Response to Complex and Simple Carbohydrates
- Glycemic Index and Glycemic Load
- Calculating Glycemic Index
- Using the Glycemic Index to Improve Performance
- Contact Us
- GSSI Web (www.gssiweb.com)

With all the hype today about protein being the most vital nutrient for athletes (not true, by the way), many athletes are beginning to look at carbohydrates differently. The truth is, carbohydrates play an essential role in the diet because they are a key source of energy and provide the glucose necessary to replace the glycogen lost during training and competition.

In fact, carbohydrates eaten before and during exercise, primarily in the form of sport drinks, bars and gels, help maintain blood glucose levels and prevent premature fatigue and decreased performance. Carbohydrates are important after exercise as well, as they replenish muscle and liver glycogen, restoring the athlete's capacity for intense training and competition.

GLYCEMIC RESPONSE TO COMPLEX AND SIMPLE CARBOHYDRATES

Researchers used to think that:

- Complex carbohydrates (breads, cereals, vegetables and foods high in starch) were digested slowly and caused little change in blood glucose levels.
- Simple carbohydrates (fruit juice and high-sugar foods and beverages) caused blood glucose levels to rapidly rise and then drop precipitously.

However, current research shows that the glycemic response — the increase in blood glucose levels after a food or combination of foods are consumed—can vary greatly. In fact, some complex carbohydrates can be digested, absorbed and utilized as quickly as simple sugars, meaning that they have similar glycemic responses.

Because of this new understanding, there is confusion about which carbohydrates should be eaten to achieve the maximum performance benefit. In an attempt to clarify the issue, the scientific terms “glycemic index” and “glycemic load,” once heard only in the laboratory, have become common vernacular.

GLYCEMIC INDEX AND GLYCEMIC LOAD

Carbohydrate foods can now be classified as producing either a high, moderate or low glycemic response. The glycemic response of a food is a measure of the food’s ability to raise blood glucose (blood sugar).

Foods that produce a high-glycemic response are expected to produce a greater increase in muscle glycogen when compared to foods producing a low-glycemic response due to the rapid increase in blood glucose levels.

In an attempt to standardize the glycemic response of various foods among individuals, researchers have categorized foods using the Glycemic Index (GI). The GI gives a numeric value for the glycemic response produced by a food, so that foods can easily be compared. The calculation to determine the GI of a food is given below. The GI for a particular food or combinations of foods is determined by:

- Comparing the blood glucose response within a two-hour time period following ingestion of 50 g of that food.
- Comparing this number to that of white bread, which has an arbitrarily defined GI of 100, and is used as the standard for all comparisons. Fifty grams of glucose can also be used as a standard.

CALCULATING GLYCEMIC INDEX:

$$\text{Glycemic Index (GI)} = \frac{\text{blood glucose response test food (beans)}}{\text{blood glucose response to reference food (white bread)}} \times 100$$

Fortunately, charts containing the GI responses of a variety of foods and beverages can be used to create meals and snacks with high or low glycemic response characteristics.

Athletes can use these charts to identify the impact of certain foods and food combinations. For example, the greater the GI, the greater the change in blood glucose that will occur and the greater the glycemic load that is delivered to the body. The glycemic load is a way of expressing the impact of the carbohydrate consumed on the body, taking GI into account.

The GI only reflects how the blood glucose level will change after the ingestion of a food, beverage or meal. If an athlete eats only a small amount of a high GI food, there will only be a small rise in blood sugar because the amount of food is low.

Thus, it is important to know the amount of carbohydrate being consumed and the associated GI index. Remember that when foods with various GIs are combined, the total GI of the meal will depend on the amount of each of these foods and their individual GI values.

USING THE GLYCEMIC INDEX TO IMPROVE PERFORMANCE

Foods with a high GI cause a greater change in blood glucose and insulin, which results in greater glycogen replacement in the muscles. This is demonstrated in a study that shows glycogen replacement is 30 percent higher in well-trained cyclists who are fed high versus low GI foods for 24 hours after two hours of exhaustive exercise.¹

Unfortunately, it is not practical to plan all meals around the GI of foods. When the desire is to increase muscle glycogen, especially after intense exercise, it may be more practical to:

- Provide 50-100g (200-400 kcal) of high GI carbohydrate to athletes immediately after glycogen-depleting exercise.
- Encourage athletes to eat high-carbohydrate foods that are packed with vitamins and fiber, especially whole grains, fruits and vegetables. High GI foods and high-carbohydrate sport nutrition products can also help improve glycogen replacement and are especially helpful during times of intense training or competition.

Conversely, consuming moderate and low GI foods may also play a role in sport because these foods slowly allow glucose to enter the bloodstream. For example, it has been shown that moderate GI foods fed before endurance exercise actually help prevent the fall in blood glucose observed during 90 minutes of exercise compared to higher GI foods.² Thus, foods with lower GI scores might work in the following situations:

- Athletes who want to minimize changes in blood glucose should select more medium to low GI types of foods (beans, legumes, whole grains, fruits or vegetables). Moderate and low GI foods are good choices for mealtime when rapid carbohydrate replacement is not a critical issue.

- Athletes who are doing endurance exercise may want to consume a moderate to low GI meal before exercise to promote sustained carbohydrate availability during exercise.

The scientific thinking about and practical applications for glycemic response are still evolving. For example, a low-glycemic response could result from slower entry of the ingested carbohydrate into the bloodstream or as a result of rapid removal from the blood into the muscles. If the latter is true, then some low glycemic foods may actually be preferable for speeding recovery. Future research will undoubtedly help refine the practical recommendations for athletes.

References:

¹ Burke LM, Collier GR, Hargreaves M. Muscle glycogen storage after prolonged exercise: effect of the glycemic index of carbohydrate feeding. *J Appl Physiol.* 1993;75:1019-1023.

² Kirwan JP, O’Gorman D, Evans WJ. A moderate glycemic meal before endurance exercise can enhance performance. *J Appl Physiol.* 1998;84(1):53-59.

Melinda M. Manore, Ph.D., R.D., FACSM, is the chair and a professor in the Department of Nutrition and Food Management at Oregon State University in Corvallis, OR.

TABLE 1. HIGH GLYCEMIC INDEX FOODS (GI>85)*

Angel Food Cake	Croissant	Waffles	POP-TARTS®
Doughnut	Maltose	White Bread	SPECIAL K® Cereal
Hard Candy	Glucose	Corn Bran Cereal	Rye Flour Bread
Bagel, White	Sucrose	CRISPIX® Cereal	CORN CHEX® Cereal
Cornflakes	Barley Flour Bread	RICE KRISPIES®	
TOTAL® Cereal	CHEERIOS®	Cereal	
Raisin Bran Cereal	CREAM OF WHEAT®	Ice Cream	
Shredded Wheat	Millet	Molasses	
Raisins	Soda Crackers	Baked/Mashed	
GRAPE-NUTS®	Watermelon	Potatoes	
Commeal	Pancakes	Pretzels	
Couscous	Honey/Syrups	Sport Drinks	
Corn Chips	English Muffins		

TABLE 2. MODERATE GLYCEMIC INDEX FOODS (GI=60-85)*

Sponge Cake	Pastry	SNICKERS® Bar	Oat Bran Bread
Corn Tortilla	Pita Bread, White	POWERBAR®	Linguine
Brown Rice	MULTI-BRAN CHEX®	Chocolate	Sweet Corn
Green Peas	Cereal	Oat Bran Cereal	100% Whole
Cracked Barley	Buckwheat	Bulgur	Wheat Bread
White Rice	Orange/Grapefruit	Banana	
(long-grain)	Juice	7-Grain Bread	
Sweet Potato	Oatmeal, Cooked	Ice Cream, Low Fat	
Brown Rice	Basmati Rice	Grapes	
Mango	Kiwifruit	Durum Spaghetti	

TABLE 3. LOW GLYCEMIC INDEX FOODS (GI <60)*

Barley Kernel	Barley, Boiled	Rice Bran	IRONMAN™ Bar,
Bread	Yogurt (all types)	Apple (whole/juice)	Chocolate
Milk (whole/skim)	Grapefruit/Oranges	Peaches (fresh)	Apricots (dried)
9-Grain Bread	Beans (all types)	Lentils	Pears (fresh)
Plums	Peanuts/Cashews	Tomato Soup/Juice	Brown Rice
ALL-BRAN® Cereal			Chickpeas/ Hummus

*White bread was used as the reference food (GI = 100).

Adapted from these References:

Foster-Powell K, Holt SHA, Brand-Miller JC. International table of glycemic index and glycemic load values: 2002. *Am J Clin Nutr.* 2002;76:5-56.

Trademark Acknowledgments:

CHEERIOS® and TOTAL® are registered trademarks of General Mills, Inc.

CREAM OF WHEAT® and GRAPE-NUTS® are registered trademarks of Kraft Foods Holdings, Inc.

CRISPIX®, RICE KRISPIES®, POP-TARTS®, SPECIAL K® and ALL-BRAN® are registered trademarks of Kellogg Company.

CORN CHEX® and MULTI-BRAN CHEX® are registered trademarks of Gardetto's Bakery, Inc.

SNICKERS® is a registered trademark of Mars, Incorporated.

POWERBAR® is a registered trademark of Societe Des Produits Nestle S.A: 2002.

IRONMAN™ is a trademark of World Triathlon Corporation.

GSSI Sports Science News is designed to provide up-to-date information on current topics in sports nutrition and exercise science. For further information on this or other topics, please visit the Gatorade Sports Science Institute Web site at www.gssiweb.com or The Gatorade Company at www.gatorade.com. We also encourage you to register for your free online membership with GSSI to receive the latest research on sports science topics.

In an effort to provide current and useful information via GSSI Sports Science News, comments and suggestions on this or future topics are highly valued and encouraged. Please e-mail any feedback to gssi_update@fleishman.com.

You may also contact gssi_update@fleishman.com if you would like to add or remove a name or e-mail address from the distribution list.

This information is current at time of press.
