Postprandial Glycemic Response in Three Male Endurance Athletes

Marie Dunford and Charlotte Saunders

The determination of blood glucose response to various carbohydrate foods may help athletes in their choice of preexercise feedings. This case study documented the postprandial glycemic responses of three male endurance athletes at rest after ingestion of 50-gram portions of three carbohydrate foods: graham crackers, orange juice, and oatmeal. Plasma glucose response differed in each subject for each test food. Two of the three subjects exhibited similar glycemic responses, but not to the same test food. Future studies will clarify the relationship between carbohydrate ingestion and postprandial glucose response.

Key Words: carbohydrate, glucose, preexercise feeding, exercise

For many years the body’s response to carbohydrate foods was thought to be predictably different. Simple carbohydrates were believed to be rapidly digested and absorbed, resulting in a steep rise in blood glucose shortly after ingestion. Complex carbohydrates were believed to produce a different response: slower digestion and absorption resulting in a flatter glycemic response over time. However, in the last decade it was determined that carbohydrate foods did not always mirror the predicted physiological response. Carrots and cornflakes, for example, produced a greater glycemic response than sucrose or orange juice. Different glycemic responses have been observed in both diabetic and euglycemic individuals (1, 2, 6–11, 15, 16, 17, 19, 24).

The rate of carbohydrate digestion has been studied in an effort to explain observed differences. Variables that appear to determine the rate of digestion include the amylose and amylpectin content of the starch, the processing of the food, the presence of dietary fiber and/or antinutrients, and the gastric emptying rate (8, 11, 14, 15, 17–19, 21–23). Amylose is hydrolyzed less readily than amylpectin, and foods with a higher content of amylose show a decreased rate of digestion and a lower glycemic response. The high amylose content of legumes may partly explain the flat glycemic response (17, 18). Foods processed by commercial methods produce higher glycemic responses than foods prepared by conventional cooking methods (15, 22, 23).

M. Dunford is with the Dept. of Enology, Food Science and Nutrition at California State University, Fresno, Fresno, CA 93740-0017. C. Saunders is with the Dept. of Family and Consumer Education at Bakersfield College, Bakersfield, CA 93305.
The presence of fat has long been known to delay gastric emptying time \((11, 15)\). Recent studies have suggested that particle size, as well as fat content, may alter the time required to leave the stomach \((8, 14, 19)\). Soluble dietary fiber decreases the postprandial glucose response whereas the insoluble fibers have little effect \((8, 11, 17–19)\). Additionally, antinutrients associated with dietary fiber (e.g., phytates and tannins) decrease the glycemic response in vivo \((15, 17, 19)\). Clearly many properties associated with food may influence the blood glucose response in humans who ingest those foods.

The importance of dietary carbohydrate to athletic performance is indisputable \((4, 5, 13, 19, 20)\). Depletion of muscle glycogen is known to limit performance, and it is speculated that the development of hypoglycemia may also be a factor. Athletes experiencing hypoglycemia have reported dizziness, lightheadedness, nausea, lack of coordination, and reduced ability to concentrate \((4)\). Thus, carbohydrates with flat and low glycemic response curves may benefit the athlete by slowly supplying glucose to the blood from the intestine and maintaining blood glucose levels.

The influence of elevated blood glucose levels prior to exercise on performance remains equivocal \((3, 13, 25)\). Studies have shown that elevated plasma glucose within 45 min prior to exercise may reduce endurance performance \((13)\), enhance endurance performance \((25)\), or have no effect on endurance performance \((3)\). For individuals who respond negatively to increased blood glucose levels prior to exercise, wise preexercise feedings may prevent such a response.

In a recent study of eight trained male cyclists, Thomas et al. \((24)\) determined that time to exhaustion was significantly longer when lentils were consumed than in the trials with other foods. Blood analysis showed that lentils produced significantly lower glycemic and insulin responses prior to exercise. Thus, determining glycemic responses to various carbohydrate foods and their utility for increasing the length of time to exhaustion may be important information for endurance athletes.

**Methods**

Three healthy volunteers were selected. Informed consent was obtained and the research was approved by the Committee on the Protection of Human Subjects. Each subject was within an acceptable range for body weight as measured by the Body Mass Index \([\text{weight (kg)/height (m)}^2]\). All were male endurance athletes between the ages of 20 and 30. Subject characteristics are shown in Table 1. A known food allergy, use of any prescription or over-the-counter medications, or an abnormal oral glucose tolerance test precluded involvement in the study. Blood samples were drawn by laboratory personnel at the student health center. A minimum of 1 week elapsed between the sessions.

Fifty-gram carbohydrate portions of the test foods were prepared in the food laboratory. All of the test meals were prepared at one time and frozen with the exception of oatmeal. The oatmeal was frozen in the dry state and prepared during the hour before the test. The test meals consisted of the following foods (order was randomized): 2 cups of canned, unsweetened orange juice, 77.8 g of instant oatmeal prepared with 1.75 cups of water, and 61.2 g of plain graham crackers. Each meal also included at least 250 ml of water.
Table 1

Subject Characteristics

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Sex</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>Body mass index</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>M</td>
<td>1.88</td>
<td>79</td>
<td>22.3</td>
<td>Cyclist</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>M</td>
<td>1.73</td>
<td>73</td>
<td>24.3</td>
<td>Triathlete</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>M</td>
<td>1.80</td>
<td>73</td>
<td>22.5</td>
<td>Cyclist</td>
</tr>
<tr>
<td>Avg.</td>
<td>25</td>
<td></td>
<td>1.80</td>
<td>75</td>
<td>23.0</td>
<td></td>
</tr>
</tbody>
</table>

Subjects fasted for a minimum of 12 hrs prior to ingesting the test food. Repeated venipuncture blood samples from the same vein were drawn immediately prior to food ingestion (0 min) and at 30, 60, 90, and 120 min postprandial. Serum glucose was determined through standardized laboratory procedures (12). Throughout the blood drawing sessions, subjects were seated and read quietly.

Results and Discussion

Glycemic responses of the subjects after consuming each test food are shown in Figure 1. Each subject responded differently to the test foods. At 30 min, postprandial glucose response was highest for graham crackers (Subjects 1 and 2) and orange juice (Subjects 2 and 3). After ingestion of graham crackers, Subject 1’s serum glucose peaked at 124 mg/dl. Similarly, the second subject’s plasma glucose level was 121 mg/dl. Both subjects’ serum glucose declined sharply within the next 30 min to 67 and 73 mg/dl, respectively. Subject 2 had a similar postprandial rise in glucose for orange juice (123 mg/dl). This response was mirrored by Subject 3 (120 mg/dl) but not Subject 1 (91 mg/dl).

Plasma glucose responses of all subjects for the test foods are shown in Figure 2. Two of the three subjects responded in a similar manner to each test food; however, the similar responses were not predictable. For example, Subjects 1 and 2 recorded a similar peak and decline pattern for graham crackers. Near identical responses were recorded for Subjects 1 and 3 to oatmeal, and Subjects 2 and 3 to orange juice. Based on average values, at 30 min the graham crackers elicited the highest glucose response, followed by orange juice and oatmeal. A review of the literature suggests that such results would be expected, since graham crackers have a higher glycemic index value than orange juice or oatmeal (16).

Summary

The present case study illustrates that male endurance athletes may exhibit varied plasma glucose responses to carbohydrate foods ingested after an overnight fast. Although the small sample size is a limitation, the results suggest that differences do exist, and further studies will help clarify the relationship between carbohydrate
Figure 1 — Glycemic response to all foods by subject.
Figure 2 — Glycemic response for all subjects by food.
ingestion and blood glucose response. Until more research results are available, glycemic index should not be used to predict an individual’s blood glucose response to a specific food.

References


Acknowledgments

This project was supported by a California State University Mini-grant. We would like to thank Robert Paull, M.D., M.P.H., Director, and the staff at University Health and Counseling for their assistance. Special thanks to the subjects who participated.