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# Caribbean Sports and Nutrition: Focus on the Glycemic Index

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**Abstract**

Caribbean athletes have displayed their admirable talents at global events for many years. More recently, they have become world champions and record holders. Given the small size of the Caribbean population these mighty achievements are truly remarkable. Even more remarkable is the fact that these athletes seldom utilize one of the most important performance enhancers – nutrition this paper highlights the value of appropriate uses of carbohydrate, particularly the glycemic index, in various sporting activities. While every sport has its own training demands the paper emphasizes that every sport should also have its own nutritional demands. To build on the inherent talent, Caribbean athletes can use the commonly available foods in a coherent nutrition program which can help to gain even more glory for this region.

**Keywords**

Sports, Nutrition, Glycemic index, Caribbean

## Introduction

The Caribbean is well known around the world for its prowess in sporting activities such as cricket, athletics, boxing, football swimming, netball, among others. The talent that exists in this small region is remarkable for its size and this natural talent is the main reason for our success over the years. During the last decade much more attention was given to coaching, administration, sponsorship and physical preparation. Good as this is, it is not enough. Physical training is essential to achieve success in sports but the very best results can only come through a combination of professional training and good nutrition [1]. In the Caribbean, unfortunately, not enough planning has gone into the nutritional aspects of the athlete's preparation before, during and after sports events. The question then becomes: how would Caribbean athletes perform if they utilized a nutrition program geared to optimize their talents in the different sporting events? This paper focuses on one aspect of this nutrition imperative – the glycemic index.

It is well known that the diet which is optimal for health should also be optimal for sports performance. For certain athletic events, however, modifications and specific recommendations relative to the use of nutrients may enhance performance. For sports performance it is the biochemical and physiological function of food that is critical. Caribbean coaches and athletes should therefore be aware of the importance of the glycemic index of commonly consumed foods in the region. The three basic purposes of food are – to provide energy, to regulate metabolic processes and to support growth and development. For athletic competition the first two functions are very important. For training in preparation for competition – all three functions are necessary.

Before we consider the glycemic index of these foods it is useful to recall what are the barriers to optimal performance. Does nutrition have a role in reducing these barriers?

## The secret of performance

To perform maximally an athlete should avoid fatigue. This means the training program of the athlete must consider three important aspects that contribute to fatigue:- physiological, psychological and biochemical [2].

1. To enhance power through physiological training focus must be on the energy system relative to that event. This system will increase energy stores, enzymatic activity and metabolic efficiency thus enhancing energy production.

2. To gain mental strength psychological training must focus the mind to tolerate stresses at high levels of competition in that event.

3. For biochemical training the mechanical skills should be maximized to decrease fatigue and attain optimal performance.

Pre-mature fatigue can therefore be deterred through proper physiological, psychological and biochemical training - all of these can be influenced by what the athlete eats. A deficiency of almost every nutrient may be a causative factor in the development of fatigue. Nutrition is therefore of critical importance in delaying the onset of fatigue during sports training and competition.

It is now proven that athletes who do not adhere to the nutritional guidelines for their particular sport perform only at sub-optimal levels. The special requirements for speed, strength and endurance events must be carefully planned and executed. It is therefore critically important that Caribbean sports administrators, coaches, trainers, counselors and the athletes themselves become familiar with the nutritional preparation that is required to maximize the enormous talent which resides in this region.

## The secret of nutrition

Because either too little or too much food intake can hamper athletic performance it is essential that the type, amount, composition and timing of food intake be considered to optimize performance,

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recovery, body weight and composition. Current state-of-the-art training requires that the nutrition program provides the necessary energy, such as through carbohydrate and fat, but also to ensure optimal metabolism of the energy substrate *via* protein, vitamins, minerals and water [1]. The secret of nutrition can therefore be put very simply - the flow of energy into the body comes from the diet and energy flow out is primarily determined by basal energy requirements and physical activity. The most vital aspect to maximal performance in most sports is body composition. Changes in storage are primarily reflected, at least over the long term, by increases or decreases in body fat. So while sound nutritional choices may not guarantee athletic prowess it is clear that consistently making poor nutritional choices will certainly constrain performance.

The Caribbean dietary patterns have changed profoundly in recent decades. Several factors influence the types and amounts of foods we eat, and this presents a challenge to the competitive and recreational athlete. We note a rapid nutrition transition where the diet is now high in saturated fats, sugars and refined foods and low in fiber [3]. Unchecked, this patterns of dietary behavior will continue to evolve under the influence of growing urbanization and increasing globalization of the food supply. Lifestyle practices are clearly vital to health and wellbeing of the average individual but even more importantly for the athlete. So, will the usual balanced diet that brings about health benefits in normal physical activity also be adequate for people engaged in increased physical activity and competitive sport? Many athletes do not think so and they are therefore exposed to, and are tempted by, numerous fads, supplements and diets which they expect to improve their performance and give them a clear advantage over their competitors. These special foods usually cost more and have a special attraction for coaches and athletes not only because of their perceived nutrient value but also because of the psychological boost to athletes who believe they are receiving special treatment. While this paper focuses on the glycemic index it is instructive to note the overall importance of nutrients to the competitive athlete.

## The competitive athlete

Although the basic principle of feeding the competitive athlete is similar to the average healthy person, recent research indicates that there are some important differences.

### Fat

Consuming foods rich in fat immediately before competition may retard performance but it can be added to a nutritional recovery plan after an event as it does not appear to interfere with glycogen recovery. Although fat is an important energy source for low and moderate intensity exercise, it is not the ideal energy source during high-intensity aerobic or anaerobic exercise. Endurance athletes are better fat burners and can also benefit during aerobic exercise. Moderate amounts of healthy dietary fat, may also help to support hard training. Benefits include anti-inflammatory effects, preservation of energy balance, bone mass and reduction in cartilage breakdown [4]. This means exercise duration and intensity greatly affect body fat biochemistry and thus could be manipulated to improve body composition while enhancing the outcomes for particular events [5]. Despite these positive observations, current research does not support fat loading or the use of various fat supplements to improve performance. Trans fats should be avoided and saturated fats used sparingly [6]. Inexpensive good quality sources in the Caribbean include butter, sections of beef, cream cheese, soyabeans and cashew nuts.

### Protein

It has been traditionally accepted that exercise has little effect on protein/amino acid requirements. Recent research, however, indicate that for both strength and endurance athletes exercise does, in fact, increase protein/amino acid need. For endurance athletes, regular exercise may increase protein need by 50 to 100% [7-9]. For strength athletes the data are less clear, however, protein intakes in excess of sedentary needs may not necessarily enhance muscle development. Contrary to the belief by some strength athletes that more protein is important to build muscle, it is the strength training that leads to increased muscle mass. Hence they actually require high carbohydrate intake and adequate glycogen stores to fuel their workouts, rather than increased protein intake [7,6]. Despite these observations increased protein intake may not improve athletic performance because many athletes routinely consume 150 to 200% of sedentary protein requirements. This means a diet containing 12 to 15% of its energy from protein should be adequate for both types of athletes [10]. The recommendation is that strength athletes need about 1.2 to 1.7 grams per kilogram of body weight per day and endurance athletes need about 1.2 to 1.4 grams per kilogram of body weight per day [11]. Caribbean athletes have available relatively cheap high protein food sources such as fish, chicken, turkey, beef, milk, yogurt, cheese, eggs, and peanut butter, among others.

After the workout, research has demonstrated that consuming a source of protein within 30-60 minutes when combined with a source of carbohydrate, has improved strength, reduced muscle soreness and inflammation, increased muscle fiber size, and protein synthesis [12]. While about 20 to 25 grams protein after a workout optimizes muscle growth, consuming excess protein displaces carbohydrates [9,13]. In short, it is best to consume a source of protein, preferably in liquid form, 30 minutes before workouts and within 30-60 minutes after workouts.

### Micronutrients

Vitamins C and E not only prevent cardiovascular disease [14] but of all the vitamins, only vitamin C and E may enhance recovery after an endurance event or a session of strength training [6,1]. Current research does not support supplementation with individual vitamins. With a normal diet, deficiencies are rare and supplementation has not been shown to improve performance. Athletes with a habitual poor nutritious diet should take a high-quality multivitamin as an easy and cost-effective way to ensure the proper intake of all the essential micronutrients. The absorption rate for most minerals is relatively low and many minerals may be harmful when taken in excess. Of all the minerals, only iron has been shown to improve performance and exercise may increase the need for iron by 30%. Athletes at risk should ensure adequate intake of iron and supplement if they are not meeting the recommended dietary intake [15,16]. Commonly available iron sources in the Caribbean include beef, liver, fish, dark green leafy vegetables and red beans.

### Carbohydrates – The key fuel

It is well established that carbohydrate is the most important energy food for exercise. Besides being the only food that can be used for anaerobic energy production in the lactic acid system, it is also the most efficient fuel for the oxygen system. But while the body uses energy from mainly carbohydrates and fat to supply the body with the energy needed for physical activity, as the amount and intensity of exercise increase carbohydrate plays a greater role [17]. It is here the type of carbohydrate available becomes crucial for the various sporting activities of Caribbean athletes. For persons who are not very active, it is recommended that at least 55% of daily energy consumption should come from carbohydrate [3]. However, for athletes and active persons, the diet should include at least a 60% contribution from carbohydrates (as well as 25-30% from fat and 10 to 15% from protein). Even this high intake of carbohydrate may not be enough to prevent depletion of the body's carbohydrate stores when an athlete is in daily training, exercise or competition and there may be a need for increased amounts [18].

During all sporting events the levels of blood glucose, liver glycogen and muscle glycogen are keys for energy production. If they are not maintained at optimal levels both hypoglycemia and depleted muscle glycogen may precipitate fatigue. Runners who dominate world competition in endurance running events, subsist on a diet that is about 75% carbohydrate. Elite marathon runners may use about 4-5grams of carbohydrate per minute. Blood lactic acid levels increase during high-intensity exercise and for years have been thought to be

**Table 1:** Glycemic Index of Selected Foods. Source: [21,22]

| Food | Glycaemic Index |
|---|---|
| Glucose [reference] | 100 |
| Cassava (boiled) | 92 |
| Cornflakes | 81 |
| Dasheen (boiled) | 80 |
| French fries | 75 |
| Iced cupcake | 73 |
| Popcorn | 72 |
| Whole wheat flour | 71 |
| Water crackers | 71 |
| White bread | 70 |
| Potato (boiled) | 69 |
| Whole wheat crackers | 67 |
| Corn chips | 63 |
| Yam (boiled) | 63 |
| Green banana (boiled) | 62 |
| Roti (boiled) | 62 |
| Ice cream | 61 |
| Sweet potatoes | 61 |
| Eddoes (boiled) | 61 |
| All bran cornflakes | 60 |
| Tannia (boiled) | 60 |
| Pawpaw | 59 |
| Pineapple | 59 |
| Breadfruit (boiled) | 59 |
| Honey | 55 |
| Oatmeal cookies | 55 |
| Brown rice | 55 |
| Ripe banana | 52 |
| Mango | 51 |
| Baked beans | 48 |
| Bulgur | 48 |
| White rice | 47 |
| Chocolate | 43 |
| Orange | 42 |
| Pear | 38 |
| Skim milk | 32 |
| Split peas | 32 |
| Yoghurt (sweetened with sugar) | 31 |
| Chickpeas | 28 |
| Kidney beans | 28 |
| Whole milk | 27 |
| Yogurt (artificially sweetened) | 24 |
| Peanuts | 14 |

the cause of fatigue. But recently it was shown that the lactate molecule *per se* does not cause fatigue, rather its accumulation in blood reflects a disturbance of muscle cell homeostasis [19]. Glycogen depletion correlates with fatigue. Conversely, increasing stores of glycogen, known as super compensation, can enhance performance [20]. For these reasons it is instructive to examine the types of carbohydrate and their effects on exercise nutrition. Clearly, just as proper physical training is essential to optimize carbohydrate utilization during exercise equally so is proper carbohydrate nutrition.

The key nutritional consideration for optimal performance in sport is the need for additional energy. The major determinant of the amount of exercise that can be performed is the carbohydrate stored in the muscle as glycogen. The challenge therefore is to make the glycogen last for as long as possible. There is a long established method to increase the amount of available glycogen and this entails loading the body with carbohydrates. The practice of carbohydrate loading enables athletes to increase muscle glycogen in preparation for specific events of more that 60 minutes duration. This process refers to a regimen of exercise and low/high carbohydrate diets in preparation for an event. The conventional carbohydrate loading regimen which resulted in side effects such as dizziness, irritability and a diminished exercise capacity has been re-evaluated. Research has shown that simply changing to a high-carbohydrate diet combined with one or two days of rest or reduced activity levels, will effectively increase muscle and liver glycogen [20]. Carbohydrate intake can be increased from 50% to 70%. This regimen results in an increase in muscle glycogen and hence improved performance. So which carbohydrates should Caribbean athletes use and when?

## The Glycemic Index and Sports Performance

The glycemic index refers to a system used for classifying carbohydrates according to the degree to which they raise blood glucose concentrations [21]. Having an overall knowledge of the glycemic index of foods can help persons select according to whether they are preparing for exercise, participating in a sports event or recovering from a strenuous activity. Table 1 shows the glycemic index of popular Caribbean foods. Source: [21,22].

### Intensity

Most Caribbean athletes currently participate in high intensity events. Because these events require short bursts of power, the traditional thought was that diet would offer little advantage to their performance. However, research has shown that a proper diet enhances all athletes' performance, regardless of body size or type of activity performed. Sound dietary practices for strength/power athletes are as critical as proper training practices.

For moderate range intensity of exercise, the rate of glycogen use is related to the intensity of exercise: the greater the intensity, the more glycogen used. It is noted however that maximal intensity exercises demand high rates of energy production. Under these conditions ATP resynthesize is dependent upon phosphocreatine and anaerobic glycogenolysis [20,18]. For these exercises glycogen availability is not the limiting factor. During maximal intensity exercises of brief duration, carbohydrate loading therefore has no beneficial effects. It is the availability of an adequate concentration of phosphocreatine which dictates whether we perform well with brief periods of exercise of maximum intensity. It should also be noted that the effective amounts of the phosphocreatine required are far in excess of the quantity available in commonly available foods [20].

The proper timing of nutrient intake is also important. Research has shown that the proper timing of the meal in sync with the exercise regimen may optimize performance [23]. The strength / power athlete should habitually follow particular glycemic index diets to optimize training, maintain weight, and promote good health. Specifically, pre-exercise nutrition should be composed of primarily low glycemic index foods. The pre-event meal should be consumed 4-6 hours before with a snack about 30-60 minutes before the event. Moderate to high glycemic index foods containing both carbohydrate and protein should be taken every 20 minutes during the event to maintain energy levels and reduce muscle protein breakdown. Moderate to high glycemic index foods containing both carbohydrate and protein are also the foods of choice after the event. These foods should be consumed within 30 minutes after the competition to take full advantage of the anabolic hormonal profile that exists post-exercise.

### Endurance

The main challenge of endurance athletes is to consume adequate calories while maintaining lean body weight and meeting key nutrient and fluid needs. The daily training schedule of endurance athletes suggest that eating the right foods in optimal amounts at the right time is crucial to maintaining health and performance [24]. As the duration of exercise increases there is generally an increase in the amount of fat used and a relative fall in the use of glycogen. This mechanism increases the capacity for fat oxidation, thus spreading glycogen usage over a longer period of time. Consumption of a high carbohydrate diet for 3 to 4 days before another round of exercise increases resting glycogen concentrations in the previously active skeletal muscles to levels which are often greater than normal.

In preparation for competition athletes should strive to fully hydrate, and also maximize their muscle glycogen stores. During exercise athletes should try to replace fluid losses that occur, although in the Caribbean with hot and humid conditions this may not always

be possible. It is better to consume small volumes of fluids frequently (150-250 mL every 15 minutes) rather than consuming high volumes of fluid occasionally (400 mL every 30 minutes). After exercise it is important to rapidly rehydrate early with a dilute sodium solution. Athletes should aim to replace at least 150% of the fluid lost during exercise. Requirements for the daily recovery of muscle glycogen will depend on the exercise intensity and duration [6,1]. If the training duration is moderate and intensity low, 5-7 g carbohydrate/kg body weight /day should be consumed. If the training duration is moderate and the intensity is high 7-12 g carbohydrate/kg body weight/day should be consumed. And if the training is extreme (4-6 hours per day) 10-12 g carbohydrate /kg body weight /day should be consumed.

### Before the event

Nutritional intake in the meal before most competition events should increase fuel stores, provide adequate hydration and prevent both hunger and gastrointestinal distress [23]. A pre-exercise meal should be eaten about four hours before the event to prevent hypoglycemia. The choice of carbohydrate taken before competition can affect performance and the amount ingested 4 hours prior to the event should be based on body weight. The recommendation is 4-5 g/kg body weight. Foods with a low glycemic index appear to improve endurance capacity more than foods with a high glycemic index. The carbohydrate could be consumed in any of several forms including fluids such as juices, or glucose polymer solutions or solid carbohydrates such as starches. The fiber content should be minimized to prevent possible intestinal problems during the event. Fasting before an event usually results in a decrease of glycogen stores in the liver.

With less than one hour before the event athletes prone to reactive hypoglycemia should avoid carbohydrate intake, particularly high glycemic index foods. Simple sugars may actually impair physical performance is such individuals because of the adverse effects of reactive hypoglycemia, such as muscular weakness. Moreover, this same insulin response may speed up muscle glycogen utilization. This may be a disadvantage to a marathoner whose glycogen levels may be depleted too early in the race. Within one hour before the event, if carbohydrate is to be consumed, it is recommended that about 1-2 grams /kg be taken. Both glucose polymers and foods with a low glycemic index are preferred. It should be stressed that consuming carbohydrate immediately before events of short and medium duration (< 90 min) normally will not enhance performance. However, carbohydrate intake within 5-10 minutes before prolonged endurance events of 2 hours or more may help delay the development of fatigue and improve performance. During these events insulin response to glucose ingestion is suppressed. Further, secretion of epinephrine is increased. These two hormonal responses interact to help maintain or elevate the blood glucose level and prevent the hypoglycemic response that may occur in reactive individuals.

### During the event

Carbohydrate ingested during prolonged exercise can help maintain blood glucose levels and reduce the psychological perception of effort, and hence enhance performance. Guidelines for recovery were previously given. In general, there appears to be no difference between the different types of carbohydrate as a means to enhance endurance performance [23]. However, there may be some important considerations relative to the use of various carbohydrate combinations such as fructose, solid carbohydrate and low glycemic index foods. With low glycemic index foods the underlying mechanism might be a slower rate of absorption, resulting in a blunted insulin response and maintenance of high blood glucose levels during prolonged exercise – an effect associated with soluble fiber. Before a clear recommendation is given there is need for more research to evaluate the effect of a low glycemic index diet in such circumstances.

During rest and low intensity activity energy comes mainly from breakdown of fat into free fatty acids. As exercise increases there is a shift away from the use of fat to using more muscle glycogen and a small proportion of energy now comes from blood glucose and free fatty acids. After about 30 minutes to an hour muscle glycogen becomes depleted. Feedings every 15-20 minutes could be recommended, but in hot Caribbean temperatures it could be more frequent. As exercise continues muscle glycogen stores become low and high intensity cannot be maintained. The rate of glycogen depletion depends on the level of fitness – depletion is not as quick if the fitness level is high. However, if there are several days of heavy exercise or training the rate at which glycogen is depleted begins to exceed the rate at which it can be replaced in the muscle. If a period of several days separate exercise or competition, inclusion in the diet of 4 to 5 grams of carbohydrate per kg body weight will usually be enough to replace muscle glycogen stores. If there is daily training or competition this will need to be substantially increased.

### After the event

After a sports event, the tissues are undergoing repair and reproduction, fluid balance is restored and substrate stores are replaced. Carbohydrate replenishment is important during this time. It should be noted that ingesting carbohydrate during the rest interval between two prolonged exercise bouts improves performance in the second bout. The carbohydrate can help restore blood glucose levels but may also be used to resynthesize muscle glycogen [23]. High glycemic index foods, such as potatoes, bread and glucose would be the preferred source of carbohydrate, for they apparently lead to a faster restoration of muscle glycogen than does a meal rich in low glycemic index foods. Intake of foods with a high glycemic index such as a high carbohydrate drink plays the dual role of replenishing muscle glycogen and quenching thirst.

In sports it is recognized that individuals have different reactions to carbohydrate intake. Just as athletes train their muscles to learn their capacity they should also train their digestive system to know its limits. Coaches and athletes should therefore experiment in training with the recommended glycemic index foods at the various stages before and after the event before developing a regime for each specific athlete during competition.

## A Note on the Vegetarian Diet

In most Caribbean countries there is a rapidly growing group of elite and recreational athletes who have adopted vegetarian diets. Some world-class athletes have been vegetarians and their diets have often been cited as a reason for their success. But the avoidance of meat does not explain their success, as research shows that a diet high in antioxidants and phytochemicals may attenuate exercise-induced oxidative stress [25]. While vegetarian diets are becoming popular in the Caribbean there is a significant risk of these athletes lacking essential nutrients. Recent studies suggest the following guidelines on key nutrient for vegetarians. Although a balanced vegetarian diet can be adequate for all athletes [26] it should be recognized that athletes who abstain from animal sources of protein should not overlook the fact that adequate amounts of macro and micro nutrients are still needed to maintain good health and athletic performance [27]. Vegetarians, especially vegans, tend to have lower energy intakes and as such may have significant difficulty in meeting daily energy requirements due to the low caloric density of their diets. As a result they may have to consume 6-8 meals/snacks per day to meet energy needs.

Vegetarian athletes can obtain adequate protein from their diet provided it is high in carbohydrate content and volume and it contains a variety of plant foods such as legumes, grains, nuts and seeds. However, vegetarian strength training athletes such as weight lifters and field throwers will require more protein-rich foods in their normal diet such as soy milk shake, lentils, chick peas and beans.

### Fat

Research shows that omega-3 supplementation may be beneficial to athletes [4,5]. The vegetarian athletes who participate in high intensity events should consume such high fat foods as peanut butter, nuts, seeds, avocados and olive oil.

### Calcium

Exercise decreases urinary calcium excretion. The low animal protein and sodium diets cause less urinary excretion of calcium [28]. Because vegetarians normally consume many calcium-rich plant foods such as dark green leafy vegetables, broccoli, spinach, legumes, almonds, fortified soymilk and seeds, calcium deficiency is not a major concern for these athletes. Calcium supplementation may only be necessary if diets are unusually low in calcium content.

### Iron

The concern for iron deficiency is based on reduced bioavailability of iron from plant foods. Even though vegetarian diets contain more iron the absorption level is less (10%) compared with heme iron (18%). Enhanced iron absorption involves using citrus drinks with major meals instead of coffee or tea. Because athletes involved in intensive endurance training have increased iron losses particularly in women [15] iron supplements are recommended in the absence of iron-rich foods such as lentil, spinach, pumpkin seeds and soyabeans.

### Zinc

The absorption of zinc is low from plant foods due to the high level of phytate and vegetarians have a high prevalence of zinc deficiency [29]. Athletes need zinc to aid the metabolism of energy and the healing of tissues. Supplementation is therefore recommended. Foods such as legumes, hard cheeses, whole grain products, wheat germ, fortified cereals and nuts are good sources of zinc.

### Vitamin $B_{12}$

Research has failed to show that vitamin $B_{12}$ enhances athletic performance, however, the vitamin is important in maintaining cell structure. Vegetarians should therefore use supplements to maintain adequate levels of this vitamin.

In summary, most vegetarian diets can provide the complete nutritional requirements for all types of athletes if they contain a variety of plant-foods. In general, consumption of lentils, nuts, whole grains can enhance performance, recovery and resistance to illness.

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