HONEY AND SPORTS NUTRITION

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Principle Investigator: Richard Kreider, PhD

INTRODUCTION

Carbohydrate and Sport

Carbohydrate (CHO) is a broad term used to describe sugars involved in nutrition. CHO or sugar is one of our body's primary sources of energy for life in general, as well as during exercise. In our diet, CHO takes two forms, *simple* CHO (sugars) and *complex* CHO (starches). Following digestion, CHO enters the blood stream in the form of glucose where it circulates until it is stored in the muscle or the liver as glycogen. Some simple CHO, sugars like glucose and fructose, are found naturally in many fruits. Other simple CHO are sucrose (common table sugar) and lactose (milk sugar). Starches, which are found in grains and vegetables, are "complex" because they are simple CHO linked together into long chains. Sucrose is a manufactured sugar, as are high-fructose corn syrup and glucose polymers, the latter being a chain of more than 10 glucose molecules. Numerous commercial CHO supplements (sport drinks, sport bars, glucose tablets, concentrated sugar gels, and glucose polymer powders) are marketed to athletes. Research on the types and amounts of CHO has attempted to determine those most useful for improving sports performance.

CHO are important to athletes because they can produce energy at a faster rate for exercise if they use CHO instead of fat. Essentially, CHO is a more efficient fuel than fat. Unfortunately, CHO in the muscles and the liver has limited storage potential, whereas the body's fat supplies are extensive. CHO is also essential for efficiently burning fat.

While the oxygen energy system is designed for endurance, an insufficient supply of the optimal fuel, CHO, can limit performance.

CHO Use During Exercise

All the CHO in the diet is broken down during digestion into glucose. Some CHO foods, particularly those rich in simple CHO, have a high glycemic index, that is, they rapidly increase blood sugar. Other CHO foods, such as fiber-rich legumes and vegetables, have a low glycemic index. Once in the blood, an increase in blood glucose concentration stimulates the release of the hormone insulin, which facilitates the transport of glucose from the blood into the liver and muscles.

The rate at which the muscles use glycogen depends on how intensely one exercise. If you perform high-intensity *anaerobic* exercise (e.g., weight lifting, vigorous tennis, basketball), you use the glycogen in your muscles at a fast rate. This type of exercise may result in the rapid production of lactic acid, which is typically associated with the development of fatigue. During *aerobic* exercise, you use a combination of muscle glycogen and fats as the energy sources for your muscle fibers. As you increase the intensity of your aerobic exercise, however, you use proportionally more glycogen than fats because glycogen is a more efficient fuel.

Because you cannot store large amounts of glycogen in your muscles, glycogen may last for only an hour or so during high-level aerobic exercise. As muscle glycogen stores deplete, the liver releases stored glycogen into the blood as glucose. Once in the blood, it is delivered from the liver to your muscles, allowing you to maintain energy production at a given level. As you become better trained aerobically, your muscles make several adaptations to help improve your performance. In essence, they develop a greater ability to use both CHO and fats as sources of energy during exercise. The ability to

oxidize fats at a faster rate allows you to substitute fat for CHO as an energy source. By using proportionately more fat, exercise training helps you spare some of your CHO stores.

HONEY STUDY SERIES

Research has indicated that ingesting CHO prior to and/or during exercise can improve endurance performance capacity by helping maintain blood glucose concentrations and CHO oxidation toward the end of an exercise bout. (Costill and Hargreaves 1992) Research also indicates that ingesting CHO (with or without protein) following exercise may influence muscle glycogen resynthesis and protein synthesis. (Zachwieja et al. 1993) For this reason, athletes commonly ingest CHO prior to, during and/or following exercise in an attempt to optimize CHO availability during exercise and enhance recovery from exercise.

Pre-exercise: Pharmacokinetics And Glycemic Index

Different types of CHO have varying effects on glucose and insulin responses. The glycemic index (GI) is a ranking of foods based on the blood glucose response compared to a reference food. (Burke et al. 1998a) High glycemic index CHO (i.e., dextrose and maltose) typically produces large increases in glucose and insulin concentrations while moderate glycemic index CHO (i.e., sucrose and lactose) typically produces modest increases in glucose and insulin concentration. It is generally recommended that athletes ingest low to moderate GI forms of CHO prior to and/or during exercise in order to enhance CHO availability without an excessive increase in insulin responses.

A number of CHO sources are available to athletes including glucose-electrolyte solutions (sports drinks), energy bars, and more recently pre-packaged sport gels. Sport gels have become popular among athletes because they are compact, convenient to transport, easy to digest, and provide a greater amount of CHO than traditional sport drinks. Most sport gels contain a mixture of various of forms of CHO (i.e., fructose, sucrose, maltodextrin, etc) with or without other nutrients (vitamins, minerals, amino acids, etc).

Although CHO sport gels have become a popular form of CHO for athletes, little is known regarding the GI response of various types of CHO gels. A recent study examined the GI and insulin responses of ingesting different types of CHO in gels to ascertain which types of CHO gels may be more or less advantageous for athletes to consume prior, during, and/or following exercise. One of these gels was CHO in the form of honey, compared to fructose, dextrose (glucose), sucrose, maltodextrin and a popular commercial product, Power Gel™.

At the conclusion of the study during which 71 subjects fasted for eight hours, the investigators found that dextrose, sucrose, maltodextrin, honey and Power Gel™ significantly increased blood glucose levels following ingestion. When ranked in order from lowest (slowest) to highest (fastest), the glycemic index of each CHO gel was:

Fructose = 5

Honey = 35

Power Gel™ = 43

Sucrose = 71

Dextrose = 100

Maltodextrin = 121

Another consideration from this same trial is the insulin response associated with each gel. This is called the insulin response index or IRI. Comparisons between the gel groups showed that maltodextrin has the highest (fastest) IRI. When ranked from lowest to highest, the IRI for the gels were:

Fructose = 41

Honey = 59

Dextrose = 100

Power Gel™ = 113

Sucrose = 147

Maltodextrin = 158

These results demonstrate that when honey is taken in its natural “gel” form, it provides a low glycemic response or slow release of sugar into the blood accompanied by a low insulin response. Because high glycemic food ingested immediately prior to exercise may actually hasten the use of muscle glycogen, honey is a useful food source prior to exercise.

During Exercise

CHO ingestion has long been recommended as a means of improving cycling performance. Recent studies suggest that CHO and electrolyte solutions may improve 40-km time trial performance by 32 to 42 seconds depending on the ability of the rider. (Jeukendrup and Martin 2001) To date, many sports supplements contain CHO in high glycemic forms and are comprised of either glucose polymers or maltodextrin. While these forms of CHO work, they are more expensive than other CHO sources, such as honey.

As research has continued to elaborate on the effects of CHO during exercise, some interesting findings have surfaced over the past few years. Specifically, recent investigations found no difference in a 30, 50 or 120-minute exercise performance when comparing a high versus low glycemic index CHO source. (Febbraio et al. 2000; Burke et al. 1998b) One possible reason that has been proposed is the glycemic index of the CHO source as both CHO sources and foods in general contain mixed nutrients. Several different lines of inquiry have shown that mixed CHO sources, such as those containing fat and CHO, perform less adequately than CHO only. (Hawley et al. 2000; Jeukendrup et al. 1996).

The primary aim of a recent trial was to examine the effects of honey as a CHO source during a 40-mile time trial. During this study, riders participated in three rides, each with a different CHO source or a placebo. The two CHO treatments consisted of having each rider consume 15 grams of dextrose or honey prior to and every 10 miles of a 40-mile time trial with 25 ml of water. This consumption of CHO is equivalent to ingesting a 6% CHO sports drink during exercise. During the course of the trial, each rider was examined for his or her heart rate, the amount of power generated and the time to cover each 10-mile segment of the ride. The study showed that the two CHO groups were able to generate more power and cover more distance over the last 10 miles than each previous 10-mile segment. The placebo group was not able to do this.

Several key findings are supported by this investigation. First, CHO ingestion may be important for improving exercise during the late stages of more prolonged exercise bouts lasting over an hour. Second, in agreement with previous recommendations, this improvement in performance is a function of maintaining blood glucose levels during exercise. Though honey would be considered a “low” glycemic food source, the results of this study show that the CHO in honey is well digested and

performs as well as high glycemic index CHO sources during exercise. Finally, while honey did not perform better than dextrose, honey is a more affordable food option than other CHO sources.

Post-exercise: Recovery

The last facet associated with exercise is the post-exercise period. During this period, it is recommended that individuals consume CHO and protein together in a 3:1 ratio to improve glycogen re-storage and muscle recovery. It is further recommended that the ingestion of these nutrients take place within one hour following the cessation of exercise. This concept is important for the recovery process as CHO uptake into the muscle is most rapidly achieved within this one-hour window. A delay will effectively reduce this response.

A factor that has not been fully addressed in the literature is nutrient combination relative to CHO and protein type. Combined nutrient ingestion may affect gastric emptying and absorption characteristics. Recent evidence suggests that ingesting CHO and protein immediately following exercise may promote glycogen restoration and a favorable hormonal environment for protein tissue restoration. (Tarnopolsky et al. 1997) For example, an investigation examining the effect of CHO, protein or CHO plus protein immediately after resistance training showed that subjects ingesting CHO or CHO plus protein had higher insulin concentrations than those who ingested protein alone. (Chandler et al. 1994) During this same trial, the CHO plus protein group also had an increase in growth hormone greater than subjects under control or protein only conditions. The authors of this study suggest that the increase in insulin and growth hormone concentration may facilitate a more favorable environment for recovery than CHO alone. (Chandler et al. 1994) Other studies have also shown that ingestion two

hours before, immediately following post-resistance training and chronic supplementation with a CHO and protein mixture during three consecutive days of resistance training increased blood glucose, insulin, growth hormone, and IGF-1 versus a placebo. (Kraemer et al. 1998)

To date, few studies have differentiated between CHO types when ingested with protein during exercise recovery. This is an important consideration because factors such as the glycemic index of foods and overall nutrient density may or may not enhance glycogen storage by promoting a greater glucose appearance and insulin response. (Burke et al. 1993)

In a recent study, recovery following weight training was examined by manipulating the CHO source accompanying the co-ingestion of whey protein after an exercise bout of resistance trained young men and women. For this study, these 39 weight trained athletes underwent an intensive weight lifting workout and immediately consumed a protein supplement blended with one of three CHO sources. The primary results from this trial showed that post exercise ingestion of CHO as honey powder, combined with whey protein, elicited a significantly *greater* increase in glucose concentration 30 minutes following exercise than combinations containing sucrose or maltodextrin. These findings are important because the rapid appearance of glucose in the blood following exercise is essential to recovery. This is particularly true when considering the ingestion of combined CHO and protein sources following exercise, which typically blunts the appearance of nutrients into the blood stream. These findings are important because research has shown that CHO/glucose availability is the most important factor in determining the rate of glycogen replacement. (Ivy et al. 1988; van Loon et al. 2000)

This premise is supported by the observation that glycogen levels in previous studies are not increased further despite higher insulin concentrations in subjects ingesting CHO plus protein. (van Hall et al. 2000; Zawadzki et al. 1992) Even though it has been reported that the glycemic index of the CHO source will influence glycogen repletion (i.e., higher being better when ingested after exercise compared with low glycemic index CHO rich foods, (Burke et al. 1996) the observations using honey during this trial are intriguing.

As the facets of recovery are broad, concentrating on the effects of CHO only following exercise is only one measure of the postexercise recovery response. The addition of whey protein may offer a more complete postexercise supplementation routine. Many elite athletes are consuming CHO combined with protein following competitions.

In conclusion, the combination of honey powder and whey protein performed well by increasing blood glucose concentrations. Maltodextrin also performed well, yielding similar, though not as great an increase in blood glucose concentrations. Both treatments performed better than sucrose and all supplement forms were well tolerated as determined by self-reported symptoms of hypoglycemia, dizziness, headache, stomach upset and fatigue.

Sports Performance Recommendations

Depriving the muscle of a source of CHO energy will decrease energy output during exercise. Decreased blood glucose levels (hypoglycemia) may deprive the brain of its primary energy source, thus impairing normal brain function and causing weakness and disorientation. Inadequate muscle glycogen and blood glucose may interfere with amino acid metabolism in the brain, causing fatigue by production of serotonin, a depressant neurotransmitter. Therefore, CHO supplementation will enhance exercise performance in

a variety of ways. In general, research supports the following conclusions relative to the effectiveness of CHO supplementation:

- CHO supplementation will not enhance performance in aerobic endurance events lasting *less* than 60 minutes, provided the athlete has normal levels of muscle and liver glycogen at the beginning.
- CHO supplementation may improve performance in more prolonged aerobic endurance events, particularly those 90 minutes or more.
- CHO supplementation may improve performance in prolonged, intermittent, high-intensity sport endeavors such as soccer, field hockey, and tennis.
- To be used as an energy source during exercise, ingested CHO needs to empty from the stomach into the intestines and be absorbed into the blood provided blood glucose is maintained *during* exercise.
- The amount of CHO you consume before exercise in dependent on your body weight:
    a. 4 hours before exercise: Ingest 4 grams per kilogram body weight
    b. 1 hour before exercise: Ingest 1 gram per kilogram body weight
    c. 10 minutes before exercise: Ingest 0.5 gram per kilogram body weight
- *CHO Intake During Exercise*: Research suggests that athletes may be able to use only about 30 to 60 grams of CHO ingested during each hour of exercise.
- *CHO Intake After Exercise*: For athletes who train intensely on a daily basis, including high intensity resistance, anaerobic, or aerobic exercise, CHO intake following exercise is needed to help return body CHO stores to normal.
    a. To speed up glycogen synthesis following exercise, athletes should consume about 1 gram of CHO per kilogram body weight within 15

minutes and repeat this procedure every 2 hours for the next 4 to 6 hours. After the first ingestion period, follow-up intake can be maintained through regular dietary patterns provided, that dietary intake is sufficient overall.

b. Combining protein with CHO following exercise will speed up muscle glycogen synthesis even more than CHO alone. Insulin is also an anabolic hormone and may help inhibit protein catabolism after resistance exercise. The ratio of CHO to protein, in grams, should be about 3 to 1.

Based on preliminary studies that will soon be published, honey in both powdered and gel forms appear to provide active participants with a nutritious CHO alternative for meeting their CHO and energy needs associated with exercise.

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