compromised and to ensure optimal training capacity isn't disrupted. Easy ways to achieve this are to minimise alcohol intake, and restrict total dietary fat intake. For muscle mass gain, add an additional 1000–2000 kJ/d onto your energy requirement. To fulfill remaining energy requirements, include a balance of additional protein, carbohydrate, and dietary fat, taking care to ensure that all micronutrient requirements are adequately met.

3 Carbohydrate intake during exercise: when, what and how much?

Asker Jeukendrup, *University of Birmingham, Birmingham, UK*

The benefits of carbohydrate ingestion during exercise are well described. So, the obvious question is how the supply of carbohydrates can be optimized. Although dose-response studies have not been conclusive there is some emerging evidence that high oxidation rates of the carbohydrate can be beneficial in some situations (Table). This will require the ingestion of fairly large amounts of carbohydrate, which in itself could be linked to gastro-intestinal problems. Combinations of carbohydrates (for example glucose and fructose) ingested at high rates seem to minimize the negative side effects and optimize carbohydrate delivery.

EVENT	CHOICE OF CARBOHYDRATE			
	Energy expenditure	Carbohydrate required for optimal performance and minimizing negative energy balance	Recommended intake	carbohydrate type
Exercise of < 45 min duration	>18 kcal/min	No CHO required	*	*
Exercise of 1 h duration	14–18 kcal/min	Very small amounts of CHO	*	*
Exercise > 2 h Low to moderate intensity	5–7 kcal/min	Small amounts of CHO	Up to 30 g/h	Can be achieved with most forms of CHO
Exercise > 2 h Moderate to high intensity	7–10 kcal/min	Moderate amounts of CHO	Up to 60 g/h	Can be achieved with CHO that are rapidly oxidized
Exercise > 3 h, Ironman, Tour de France stage races	10–14 kcal/min	Large amounts of CHO	Up to 90 g/h	Can only be achieved by intakes of multiple transportable CHO

Strategies to take carbohydrate on board

When

Carbohydrate ingestion can enhance performance during exercise of 45 min or longer. So if the quality of a training session is important or in competition, consuming some form of carbohydrate will help.

What

The type of carbohydrate has considerable impact on the speed of energy delivery. Some carbohydrates are oxidized at higher rates than others. However, a combination of maltodextrins and fructose, glucose and fructose, glucose, sucrose and fructose seems to result in the highest oxidation rates.

How

How the carbohydrate is ingested and in what form seems to be less important for the delivery of carbohydrate but can be important for fluid delivery. Highly concentrated carbohydrate solutions can impair fluid delivery. It is generally recommend to ingest a certaion volume at the start to prime the stomach and to keep topping this up with smaller boluses at regular intervals.

How much

How much you ingest depends on a number of factors including:
1) What type of exercise (intensity and duration; see Table).
2) The type of carbohydrate (or combination of carbohydrates).
3) Tolderance. Especially this factor is highly individually determined and only practicing in training (and competition) will help an individual find out what will work for them.

Suggested additional resources

1. Jeukendrup AE. Carbohydrate intake and exercise performance. Nutrition this issue: 2004.
2. Jeukendrup AE, and Jentjens R. Oxidation of carbohydrate feedings during prolonged exercise: current thoughts, guidelines and directions for future research. Sports Med 29: 407-424., 2000.
3. Jeukendrup AE, Jentjens RL, and Moseley L. Nutritional considerations in triathlon. Sports Med 35: 163-181, 2005.

4 Optimising training adaptations by manipulating glycogen

Keith Baar, *University of Dundee, Scotland*

The recent discovery that training in a low glycogen state may have benefits on the adaptive response to endurance exercise suggests that this may be another training tool that can be used to optimize performance.