Dietary Carbohydrate

for Female Athletes

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Introduction

All of the foods and fluids that athletes eat provide nutrients which have specific roles in the body. Carbohydrates are a macronutrient (along with protein and fat), which are required in larger quantities in comparison to micronutrients (vitamins and minerals). The information below will provide guidelines on daily carbohydrate recommendations to support both the health and performance of female athletes. In addition, it will cover some of the barriers that female athletes may face in order to meet carbohydrate recommendations.

Dietary carbohydrate

There are three main types of dietary carbohydrate which are:

Sugar

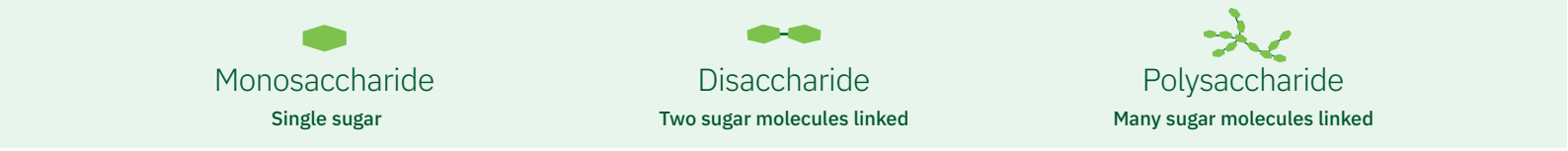
also known as monosaccharides or disaccharides because they are made up of single or double sugar molecule(s). They can be naturally occurring sugars (e.g., in fruit or milk), or added sugars which are those added during processing (e.g., fruit canned in syrup or sugar added to make a cookie). On food labels, sugar is often referred to by its chemical name (e.g., glucose, sucrose, fructose, lactose, maltose). Sugars are an energy source for the body.

Starch

also known as polysaccharides because they are more complex carbohydrates made up of multiple sugar molecules joined together by glycosidic bonds. When starches are consumed, they are broken down by the body into units of glucose, which provides energy to the body.

Fiber

a complex group of sugars (polysaccharides) from plant foods which cannot be digested in the small intestine. Instead, they are completely or partially broken down (i.e., fermented) by bacteria in the large intestine.



Carbohydrate use and storage

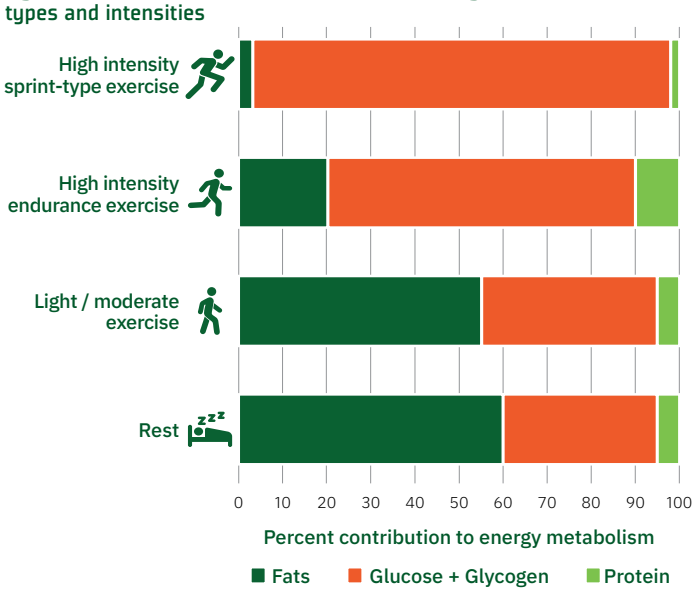
Ingested dietary carbohydrates provide energy to the muscles, brain and nervous system. Following ingestion, carbohydrates are broken down into smaller sugar molecules, which are converted into glucose by the liver to be used for energy. If glucose in the bloodstream exceeds energy needs, glucose will be converted into glycogen and stored in the body. The body can store ~500 grams of carbohydrate as glycogen in the liver and muscle, which can be broken down and used when energy is needed.

The liver can store up to ~100 grams of glycogen at any given time. This glycogen is primarily used to maintain blood sugar and energy levels throughout the day. In the muscles, a larger amount of glycogen can be stored (~400 grams). The glycogen in the muscles is a secondary storage facility, carbohydrates are stored there when the liver has reached capacity. For athletes, muscle glycogen, and the breakdown of glycogen to glucose in the liver, is used by the muscles during exercise to provide energy.

Each gram of carbohydrate provides ~4 kcal of energy.

The contribution of carbohydrate to energy metabolism during exercise changes depending on exercise type (see Figure 1). During high intensity endurance or sprint-type exercise, carbohydrates are the predominant energy source. During this type of exercise, the body will use up glycogen stores, and sometimes they may even become depleted. When glycogen stores run low, the body may fatigue which can result in impaired physical and cognitive performance.

Figure 1: Substrate metabolism at rest and during different exercise types and intensities



Daily carbohydrate recommendations

Due to carbohydrate utilization varying during different exercise occasions, daily carbohydrate intake recommendations are dependent upon the intensity and duration of exercise being performed (Figure 2). The aim is to ensure that sufficient carbohydrate is consumed to provide energy to working muscles, the central nervous system and other bodily processes. Figure 3 shows the carbohydrate content of different foods, which can contribute to overall daily carbohydrate intake.

Figure 2: Daily carbohydrate intake based on activity level

3-5 g/kg BM/day (180 – 300 g*) **Light activity**

5-7 g/kg BM/day (300 – 420 g*) **Moderate activity** (e.g., 1 hour per day)

6-10 g/kg BM/day (360 – 600 g*) **Endurance** (e.g., 1-3 hours per day)

8-12 g/kg BM/day (480 – 720 g*) **Extreme activity** (e.g., >4 hours)

*Recommendations in grams (g) calculated for a 60 kg/133 lb female
BM: Body Mass

Figure 3

Carbohydrate and fiber content of foods and drinks

Sweet potatoes
Serving size: 1 cup
Carbohydrate: ~30 g
Fiber: ~4 g

Standard potatoes
Serving size: 1 cup
Carbohydrate: ~26 g
Fiber: ~3 g

Couscous
Serving size: 1 cup
Carbohydrate: ~56 g
Fiber: ~5 g

Wholewheat pasta
Serving size: 1½ cups
Carbohydrate: ~50 g
Fiber: ~7 g

Gatorade Thirst Quencher
Serving size: 20 oz (1 bottle)
Carbohydrate: ~30 g
Fiber: 0 g

Brown rice
Serving size: 1 cup
Carbohydrate: ~46 g
Fiber: ~3 g

Banana
Serving size: 1 medium
Carbohydrate: ~30 g
Fiber: ~2 g

Oats
Serving size: ½ cup
Carbohydrate: ~30 g
Fiber: ~4 g

Wholemeal bread
Serving size: 2 slices
Carbohydrate: ~30 g
Fiber: ~5 g

Figure 4

Daily carbohydrate intake recommendations based on exercise intensity and body mass

		Light activity		Moderate activity	Endurance		Extreme activity				
Body mass		**Recommended carbohydrate intake (g) per day**									
kg	lb	3 g/kg BM/d	4 g/kg BM/d	5 g/kg BM/d	6 g/kg BM/d	7 g/kg BM/d	8 g/kg BM/d	9 g/kg BM/d	10 g/kg BM/d	11 g/kg BM/d	12 g/kg BM/d
45	99	135	180	225	270	315	360	405	450	495	540
50	110	150	200	250	300	350	400	450	500	550	600
55	121	165	220	275	330	385	440	495	550	605	660
60	132	180	240	300	360	420	480	540	600	660	720
65	143	195	260	325	390	455	520	585	650	715	780
70	154	210	280	350	420	490	560	630	700	770	840
75	165	225	300	375	450	525	600	675	750	825	900
80	176	240	320	400	480	560	640	720	800	880	960
85	187	255	340	425	510	595	680	765	850	935	1020
90	198	270	360	450	540	630	720	810	900	990	1080
95	209	285	380	475	570	665	760	855	950	1045	1140
100	221	300	400	500	600	700	800	900	1000	1100	1200
105	232	315	420	525	630	735	840	945	1050	1155	1260
110	243	330	440	550	660	770	880	990	1100	1210	1320

Figure 5: Examples of how the carbohydrate content of meals can be altered to meet daily carbohydrate recommendations

g/kg BM/day	Breakfast	Lunch	Dinner
3-5	 bowl of porridge with berries	 chicken salad and a banana	 fish with roasted vegetables
5-7	 + a banana	 + bread rolls	 + a rice based salad
6-10	 + yogurt and granola	 + a side of potatoes	 + a large glass of orange juice
8-12	 + two slices of toast	 + a milk based fruit smoothie	 + a large fruit salad

Dietary fiber

It is recommended for athletes to consume 25-35 grams of fiber per day. Dietary fiber provides many benefits to the body including:

- Improves gastrointestinal function and bowel movements
- Supports a healthy gut microbiome
- Helps to promote satiety
- Associated with lower risk of heart disease, type 2 diabetes and bowel cancer

Whilst dietary fiber intake provides many health benefits, there is reason for practitioners to be cautious if athletes regularly have a very high fiber intake (i.e. above the RDA, >35g fiber). Research in female endurance athletes found high levels of dietary fiber intake to be associated with low energy availability and functional hypothalamic amenorrhea (i.e. loss of menstrual cycle). These associations might be due to:

1. High fiber intake increasing fecal fat excretion, which in turn can reduce energy absorption
2. Dietary fiber increasing satiety, which when coupled with high intensity exercise may suppress appetite, decrease hunger and reduce the total amount of energy consumed during a meal
3. Excessive fiber increasing the likelihood of gastrointestinal disorders e.g., bloating and diarrhea, which in turn may impact subsequent energy intake

Therefore, whilst it is important for athletes to include fiber within their diet, practitioners should be aware of how much fiber female athletes are consuming.

Do female athletes meet carbohydrate recommendations?

It has been shown that female athletes across a range of sports struggle to meet daily carbohydrate recommendations, and do not adapt their carbohydrate intake based on their training load. This could be due to a number of reasons including:

- **High consumption of low-energy, dense carbohydrates (e.g. whole fruits and vegetables)**
- **Body weight and/or composition fears**
- **Substituting sports drinks with low calorie sweetener drinks during high intensity exercise**
- **Lack of education regarding the importance of carbohydrates**
- **Negative perception of carbohydrates on social media**

Meeting the upper end of the carbohydrate recommendations requires a large amount of food to be consumed, which may also be a contributing factor to female athletes not meeting the recommendations. For example, in food terms, 10 g/kg BM/day of carbohydrate for a 60 kg female (= 600g carbohydrate) is equivalent to either:

11 potatoes

1.8 kg white rice (uncooked)

1.7 kg pasta (uncooked)

*It is not recommended to eat the amounts shown above in one day, and a balanced diet is necessary

Excerpts from a qualitative study regarding carbohydrate intake in professional female soccer players bring to life some of the barriers faced by female athletes:

"It was quite difficult for me to actually transition into eating, like, more carbs and more calories because I was scared of putting weight back on. Sometimes I just don't want to eat carbs because I know they will make me fat."

– Player

"I've had conversations with players where I'm like 'you need to have carbs at least on match day minus one, making sure you're fueling for the game ahead' and they're a bit reluctant to want to take on that amount of carbs. Like 'I don't like eating that many carbs, that's not something I do.'"

– Sport scientist

"The players don't want a mixed protein shake, they just want a protein shake because the mixed protein shake has got too much carbs in and it's like 'wow, they're not willing to have carbs after a game, that's pretty scary' I guess... The fact that they're worried about some carbohydrate powder in a protein shake because they think it will make them fat is quite a scary thing."

– Nutritionist

McHaffie SJ et al (2022)

These excerpts highlight that providing education to female athletes regarding the role of carbohydrates in the diet is key. In addition, practitioners should work with female athletes on an individual basis to discuss any barriers that they face to meeting their daily carbohydrate needs, and to find ways to meet their individual carbohydrate recommendations.

Low carbohydrate diets

Some athletes may purposefully follow a low carbohydrate diet on a long-term basis, i.e., a 'ketogenic' or 'low carbohydrate, high fat' diet. This may be for a range of reasons including a lack of understanding of the importance of carbohydrates for performance, fad diets, social media influence, "carb-phobia", perceived positive body composition outcomes, etc. Very low carbohydrate intake for a prolonged period can lead to a range of outcomes including:

- Premature fatigue during exercise
- Impaired performance at higher intensities
- Poor cognitive performance e.g., reduced alertness, difficulty concentrating
- Poor recovery between bouts of exercise

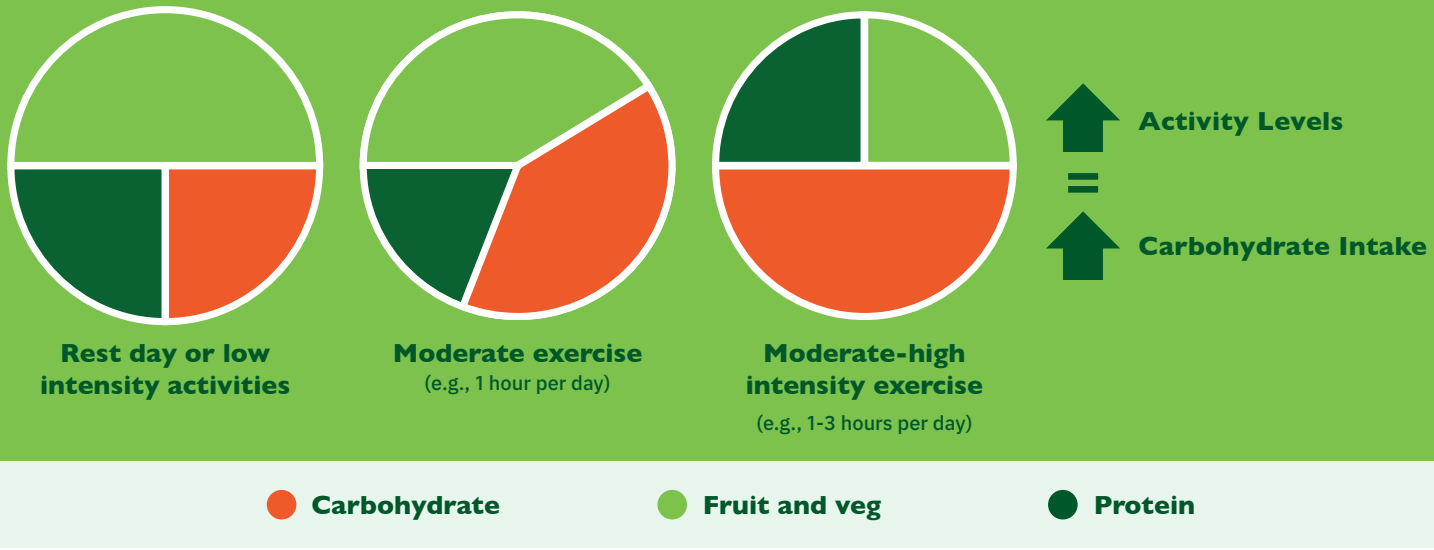
Athletes should therefore be educated around the potential performance consequences of following a low carbohydrate diet. It is however worth noting that a low carbohydrate, high fat diet may be useful during very short-term periods where weight loss is required to meet a certain weight target e.g., Olympic weightlifting, wrestling, judo and boxing. This is because there is evidence that low carbohydrate, high fat diets are effective for reducing fat mass whilst maintaining power and strength during very short-term periods. If this strategy is used, it should be carefully planned and managed by a qualified professional, and should not be used for long periods of time.

Carbohydrate periodization

If athletes need help adjusting their carbohydrate intake to meet the demands of the exercise on a day-by-day basis, carbohydrate periodization provides a practical solution. This strategy can help to support both performance and recovery through strategic timing of carbohydrate intake. Figure 6 provides a visual representation of how carbohydrate intake can be altered depending on the intensity and duration of exercise being completed.

Figure 6

How to periodize carboydrate intake based on activity levels



Does menstrual cycle phase influence carbohydrate intake?

Popular media would suggest that female athletes should alter their diet, including their carbohydrate intake, during different phases of the menstrual cycle. **However, there currently isn't enough research to back this statement.** There is some evidence to suggest that glycogen storage is reduced during the follicular phase of the menstrual cycle compared to the mid-luteal phase. Nevertheless, providing that daily carbohydrate intake is sufficient for the exercise demands, this should not have an impact on performance.

DIETARY CARBOHYDRATE

Sugar | **Starch** | **Fiber**

Carbohydrate containing foods

Sweet potatoes
1 cup ≈ 30 g carbohydrate

Standard potatoes
1 cup ≈ 26 g carbohydrate

Couscous
1 cup ≈ 56 g carbohydrate

Wholewheat pasta
1½ cups ≈ 50 g carbohydrate

Gatorade Thirst Quencher
20 oz (1 bottle) ≈ 30 g carbohydrate

Brown rice
1 cup ≈ 46 g carbohydrate

Banana
1 medium ≈ 30 g carbohydrate

Oats
½ cup ≈ 30 g carbohydrate

Wholemeal bread
2 slices ≈ 30 g carbohydrate

3-5 g/kg BM/day
180 – 300 g
Light activity

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(e.g., 1 hour per day)

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8-12 g/kg BM/day
480 – 720 g
Extreme activity
(>4 hr)

Examples based on a 60 kg/133 lb female

Activity Levels = **Carbohydrate Intake**

Carbohydrate periodization

Rest day or low intensity activities

Moderate exercise
(e.g., 1 hour per day)

Moderate-high intensity exercise
(e.g., 1-3 hours per day)

● **Carbohydrate** ● **Fruit and veg** ● **Protein**

Dietary fiber
25-35 grams per day
Be aware of regularly exceeding the RDA

Improves GI function

Healthy gut microbiome

Promotes satiety

Lowers risk of diseases

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References and resources

Boisseau, N., & Isacco, L. (2022). Substrate metabolism during exercise: Sexual dimorphism and women's specificities. European Journal of Sport Science, 22(5), 672–683.

Burke, L. M., Hawley, J. A., Wong, S. H. S., & Jeukendrup, A. E. (2011). Carbohydrates for training and competition. Journal of Sports Sciences, 29 Suppl 1, S17-27.

McHaffie, S. J., Langan-Evans, C., Morehen, J. C., Strauss, J. A., Areta, J. L., Rosimus, C., Evans, M., Elliott-Sale, K. J., Cronin, C. J., & Morton, J. P. (2022). Carbohydrate fear, skinfold targets and body image issues: A qualitative analysis of player and stakeholder perceptions of the nutrition culture within elite female soccer. Science & Medicine in Football, 6(5), 675–685.

McLay, R. T., Thomson, C. D., Williams, S. M., & Rehrer, N. J. (2007). Carbohydrate loading and female endurance athletes: Effect of menstrual-cycle phase. International Journal of Sport Nutrition and Exercise Metabolism, 17(2), 189–205.

Melin, A. K., Tornberg, A. B., Skouby, S., & Moller, S. S. (2016). Low-energy density and high fiber intake are dietary concerns in female endurance athletes. Scandinavian Journal of Medicine & Science in Sports, 26(9), 1060–1071.

Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). American College of Sports Medicine Joint Position Statement. Nutrition and Athletic Performance. Medicine and Science in Sports and Exercise, 48(3), 543–568.