



THE SCIENCE OF  
**CARBOHYDRATE**



# THE SCIENCE OF CARBOHYDRATE RECOMMENDATIONS FOR ATHLETES

This document provides an overview of the scientific literature related to the carbohydrate needs of athletes, including why and when to eat carbohydrate, what type to consume and the appropriate amount.

## INTRODUCTION

Carbohydrate (CHO) is the primary fuel source for moderate and high intensity exercise.<sup>2</sup> The stored form of CHO in the muscle and liver, called glycogen, supplies most of this fuel and can be manipulated by diet and training. The body has small amounts of CHO stored in the liver (~80 g, 320 kcal) and muscle tissue (300-500 g, 1200-2000 kcal). CHO intake throughout the day, and before and after training and competition, will help to ensure adequate glycogen stores. During training or competition of an hour or longer, CHO intake will help support this relatively limited fuel supply to help maintain performance.<sup>1,2,6,9</sup>

## DAILY CARBOHYDRATE INTAKE

Due to the additional energy demands of training, CHO recommendations for athletes are higher than the general population. The recommendations are meant to support CHO availability for the muscle and central nervous system based on the demands of the sport.<sup>2</sup> Additionally, in order to adequately support the increased energy demands, the recommendations are based on body weight rather than given as a percentage. See Table 1 for the daily CHO recommendations for athletes competing in various sports.

Daily carbohydrate needs can also be determined based on the intensity of training: 3-5 g/kg/d for light intensity, 5-g/kg/d moderate, 6-10 g/kg/d high, and 8-12 g/kg/d for very high intensity training.<sup>12</sup>

Researchers have been investigating the benefits of training on lower carbohydrate availability to manipulate endurance training adaptations. However, evidence to date does not support this strategy.<sup>4</sup>

**Table 1:** Daily Carbohydrate Recommendations for Athletes<sup>2,5,15,16</sup>

Type of Athlete	Recommended Intake (g/kg/d)	Recommended intake (g/lb/d)
Endurance-Moderate Training	6.0-10.0	2.7-4.6
Endurance-Heavy Training	8.0-12.0	3.6-5.5
Power Sport	6.0-12.0	2.7-5.5
Strength Sport	4.0-7.0	1.8-3.2
Team Sport	5.0-7.0	2.3-3.2



## SPORTS NUTRITION: RECOMMENDATIONS FOR CARBOHYDRATE INTAKE

### Carbohydrate Before Training & Competition

**Timing & Amount:** In the 1-4 h pre-exercise, the athlete should consume between 1-4 g of CHO/kg of bodyweight.<sup>2</sup> The choice of where within this range an athlete falls depends on a number of factors including the type of sport/event, goal of the athlete and any stomach issues. For example, a marathon runner preparing to complete a 20-mile training run will be on the high end of the range, whereas a football lineman preparing for a game may be on the lower end. It is important that the athlete try out various strategies with form, amount and timing to find what works best for him or her.

Within about one hour before exercise, the amount and type of CHO to consume is based on athlete preference and tolerance. Intake in this window begins to meet the “during” exercise needs for the athlete, and is particularly important if the athlete cannot or will not consume fuel during their training or competition.<sup>8</sup> Many athletes do well with about 25-30 g during this time, which is an appropriate amount when considering the during exercise recommendations discussed below.

**Type:** Before exercise, athletes should choose carbohydrate-rich foods with minimal fiber, fat and protein. These nutrients can slow the digestion and absorption process, and if consumed close to the



start of exercise, potentially cause gastrointestinal distress during exercise. All athletes should practice pre-exercise nutrition strategies to find the best timing and amount that will work for them during competition.

**Table 2:** During Exercise Carbohydrate Needs for Endurance Athletes<sup>2,9,11</sup>

Duration	CHO Amount	CHO Type
<30 Minutes	Not needed	--
30-75 Minutes	Small amounts including mouth rinse	Most forms of CHO
1-2 Hours	Up to 30 g/hr	Most forms of CHO
2-3 Hours	Up to 60 g/hr	Rapidly Oxidized CHO (e.g. glucose, sucrose, maltodextrin)
>2.5 Hours	Up to 90g/hr	Multiple Transportable CHO (2:1 glucose:fructose)

### Carbohydrate During Training & Competition

**Timing & Amount:** The amount of CHO that can be absorbed through the intestines during exercise is limited; therefore, recommendations are independent of body weight.<sup>7</sup> Team sport athletes when practicing or competing for an hour or longer, should consume 30-60 g of CHO per hour of exercise in order to support exercise performance.<sup>1,2,14</sup>

During competition, it may not be practical for athletes who participate in power sports, such as swimming, to consume CHO.<sup>16</sup> The focus on competition days should be pre-exercise CHO and post-exercise CHO intake if the athlete competes in multiple events. During training,

however, the power sport athlete may be exercising for several hours, and should therefore consume between 30-60 g/h of CHO.<sup>2,14</sup>

For endurance athletes, the recommendations are specific. Rinsing the mouth with a carbohydrate solution has been shown to improve high intensity endurance performance lasting ~30-75 minutes.<sup>11</sup> See Table 2 for the breakdown of CHO needs as duration increases.

**Type:** Team sport, power sport and endurance athletes exercising <2.5 h, should choose a CHO source that is rapidly oxidized.<sup>1</sup> Sources of CHO such as glucose (dextrose), sucrose and maltodextrin are all oxidized at a rate of ~1g/min and are appropriate choices. The

form in which the carbohydrate is consumed (drink, gel or solid) does not influence oxidation rates; therefore, athletes should choose the form that works best for them.<sup>13,14</sup>

Endurance athletes exercising >2.5 h consuming up to 90 g of CHO/h should choose a 2:1 blend of glucose and fructose to take advantage of the multiple transport systems in the gut. This results in high oxidation rates of the exogenous CHO for fuel and may reduce the risk of GI distress. For more information on multiple transportable CHOs, please see Sports Science Exchange #108 "Multiple Transportable CHOs and Their Benefits" by Dr. Asker Jeukendrup, found at [www.gssiweb.org](http://www.gssiweb.org).<sup>10</sup>

While the focus here is carbohydrate, it is important to note that during exercise athletes also need to maintain hydration. It is important for athletes to develop and practice a sports nutrition plan that appropriately combines carbohydrate for fuel as well as fluid for hydration in relation to the type of sport, duration, goals and environment.

### Carbohydrate After Training & Competition

**Timing & Amount:** The amount of CHO that can be absorbed through the intestines during exercise is limited; therefore, recommendations are independent of body weight.<sup>7</sup> Team sport athletes when practicing or competing for an hour or longer, should consume 30-60 g of CHO per hour of exercise in order to support exercise performance.<sup>1,2,14</sup>

The goal of post-exercise CHO intake is to replenish glycogen stores. The timing and amount of CHO intake post-exercise depends on the recovery time. If the athlete plans to practice, train or compete again within about 8 h,<sup>2,14</sup> attention should be paid to replenishing glycogen stores. The athlete should consume 1-1.2 g of CHO/kg/h bodyweight (0.45-0.55g/lb/h) again hourly for the first four-six hours and then resume regular dietary habits in order to quickly refuel glycogen stores.<sup>2,14</sup> While consuming CHO post-exercise is still a good habit for athletes with a greater amount of recovery time, meeting daily CHO needs should be adequate to restore muscle glycogen. Unless the athlete follows a low-carbohydrate diet, muscle glycogen stores can generally be normalized within 24 hours.<sup>3</sup>

**In order to provide appropriate carbohydrate recommendations to individual athletes, it is important that the practitioner understand the demands of the sport, training period and personal goals of the athlete.**

#### Sports Nutrition Carbohydrate Recommendations

Pre-Exercise 1-4 Hours	1-4 g/kg bodyweight (0.45-1.82 g/lb)
Pre-Exercise <1 Hour	If desired, a small amount of easily digested carbohydrate, in an amount and form the athlete prefers
During Exercise	Team & Power Sports: 30-60 g/h Endurance Sports: Dependent upon duration- up to 90 g/h
Post-Exercise <8 Hours to recover	1-1.2 g/kg bodyweight/hour (0.45-0.55 g/lb) for the first 4 hours- then resume daily fueling needs
Post-Exercise >8 Hours to recover	Daily fueling plan adequate to restore muscle glycogen (assuming adequate carbohydrate intake)



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