

Carbohydrate = Energy

Carbohydrate is a source of energy for athletes, like gasoline for an automobile. Carbohydrate is metabolized into glucose in the body. Glucose maintains blood sugar at normal levels, provides energy for the brain and can be stored as muscle glycogen. Athletes can maximize muscle glycogen store by increasing dietary carbohydrate intake. This is known as "Carbohydrate Loading".

Carbohydrate loading is suitable for endurance events of over 90 minutes, like cycling, marathon, triathlon, and events which have more than one game in a day, especially those which game time is long or unpredictable, like windsurfing, badminton, soccer, squash, tennis etc.

However, carbohydrate loading is not suitable for short and power-related events, like short putt, high jump, sprint, weight lifting, shooting, bowling etc.

Where is the glucose stored?

A sedentary person has 13 grams of glycogen per kilogram muscle, but an athlete can have 32grams of glycogen per kilogram muscle. Carbohydrate loading can increase glycogen storage to 35 - 40 grams of glycogen per kilogram muscle.

Carbohydrate Loading

60's Astrand

The traditional method for increasing muscle glycogen stores was introduced by Astrand in 1967. It was shown to be effective in prolonging endurance exercise and sports performance. Carbohydrate loading should be initiated seven days before the event. In the first four days, athletes should exercise to exhaustion and consume a low carbohydrate diet in order to deplete their muscle glycogen stores. Then, three days before the event, a high carbohydrate diet of 9-10g/kg body weight/day is consumed. For example, an athlete weighing 60kg needs to consume 540 - 600g carbohydrate per day three days before the event. At the same time, training needs to be decreased to lower energy expenditure in order to maximize stores.

碳水化合物 = 能量

運動員需要碳水化合物，正如汽車需要汽油，兩者同樣是能量的來源。

碳水化合物在代謝後會變成葡萄糖，而葡萄糖除了能維持血糖於正常水平及供給腦部能源外，還可轉化為肌糖原存於肌肉之中。運動員可從飲食中增加碳水化合物來將肌糖原儲滿，確保能源存備充足。這叫「糖原負荷法」。

糖原負荷法適合長於90分鐘的耐力性項目如單車、馬拉松、三項鐵人，以及在一天內有重複賽事而比賽時間較長或不能預計的運動如風帆板、羽毛球、足球、壁球和網球等。

糖原負荷法卻不適用於爆發力及短時間的運動如推鉛球、跳高、短跑、舉重、射擊、保齡球等。

糖份存到哪裡去？

一個普通人每公斤肌肉所儲存的肌糖只有13克，但運動員每公斤肌肉就可儲存32克肌糖。糖原負荷法能使每公斤肌肉儲存高達35-40克肌糖。



However, it is difficult to follow a low carbohydrate diet with high intensity training in the first four days. Athletes may experience overwhelming fatigue, irritability and poor immunity. It is unpleasant and may affect preparation for competition. Low carbohydrate intake and increased exercise intensity will deplete glycogen stores in the body, brain and muscles. It may result in muscle fatigue and even dizziness, which may increase the risk of injuries.

Modified Carbohydrate Loading

An alternative ways were developed in the 80's which has eliminated the depletion phase in the first four days. Athletes will increase carbohydrate intake to 9-10g/kg body weight and decrease training for three days prior to the event. Training adjustment should be decided by the coach. Glycogen will be stored in exercising muscle group, therefore, a long distance runner should not be swimming three days before the competition.

The physical and psychological detrimental effects resulting from the depletion phase of the traditional method are avoided. However, the body can still achieve similar effect for maximum muscle glycogen storage prior to the event with this modified method.

A sample diet which consists of 550g carbohydrate and 3300kcal (suitable for an athlete weighing 60kg) :

Breakfast:	skimmed milk	1 cup
	corn flakes	1 cup
	banana	1
	bread	2 slices
	jam	3 tsp
Morning Snack:	apple juice	1 cup
	chiffon cake	1 piece
Lunch:	rice	2 bowls
	green vegetables	4 oz
	chicken thigh	1 piece
	Sweetened soy milk	1 cup
Afternoon Tea:	orange juice	1 cup
	bread	2 slices
	jam	3 tsp
Dinner:	rice	2 bowls
	Chinese meat loaf	3 oz
	green vegetables	4 oz
	apple	1
	red bean sweet soup	1 bowl

糖原負荷法

60年代的糖原負荷法

Astrand於1967年提出的糖原負荷法能增加體內肌糖的儲備，提高耐力及運動表現。此做法在比賽前七天開始，首四天增加運動量並配合低碳水化合物飲食，以耗盡體內的肌糖。然後於比賽前三天，每天飲食的碳水化合物要達9-10克/公斤體重，例如：一個體重60公斤的運動員就需要從飲食中攝取540-600克的碳水化合物。與此同時亦要將運動量調低來減少消耗，保存儲備。

然而此方法的缺點是首四天的劇烈訓練及低碳水化合物飲食較難遵從。運動員可能會過度疲憊、煩躁、抵抗力降低，亦可能影響比賽前的心理狀況。增加運動量和碳水化合物過少的飲食會令全身、腦部及肌肉的糖份耗盡。運動員會感覺乏力氣、疲憊甚至頭暈，從而增加受傷的風險。

改良的糖原負荷法

於80年代提出的改良方法，免去了首四天的劇烈訓練及低碳水化合物飲食。比賽前三天開始，調低運動量及飲食達到每公斤體重9-10克碳水化合物來增加體內肌糖原的儲備。運動量的調控要由教練決定，值得注意的是肌糖會儲存在有運動刺激的肌肉組織，所以長跑運動員不要在比賽前三天以游泳作練習。此方法避免了60年代糖原負荷法對運動員比賽前生理及心理狀況的負面影響，卻能達到同樣的效果。

The following are examples of food containing 10g carbohydrates. Athletes may combine these in order to achieve the goal of carbohydrate loading (9-10g carbohydrate/kg body weight/day):

oatmeal (cooked)	1/3 cup
pasta (cooked)	1/3 cup
rice (cooked)	1/5 cup
soda crackers	2 pieces
bread	1/2 slice
corn flakes	1/2 cup
corn on the cob	1/3
carrots (cooked)	3/4 cup
baked potato	1 (egg-sized)
baked beans in tomato sauce	4 tbsps
apple or pear or orange	1 (small)
kiwi fruit	1
banana	1/2
grapes	10
canned fruit	1/3 cup
orange juice	1/2 cup
milk or soy milk	1 cup
plain yogurt	150 g
horlicks powder	15 g
soft drink	1/2 cup

References:

1. Williams, C., 2007. Carbohydrate as an energy source for sport and exercise. In D. MacLaren, ed. *Advances in sport and exercise science series: nutrition and sport*. Liverpool: Churchill Livingstone Elsevier. Ch. 3
2. Burke, L. & Deakin, V., 2006. *Clinical sports nutrition*. 3rd ed. Australia: McGraw-Hill.

The above information is provided by the Sport Nutrition Unit of the Athlete and Scientific Services Division. All information is for reference only.

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一個含550克碳水化合物及3300卡路里的餐單 (適合重60公斤的運動員) :

早餐	脫脂奶	1杯
	粟米片	1杯
	香蕉	1隻
	方包	2片
	果占	3茶匙
上午茶	蘋果汁	1杯
	清蛋糕	1片
午餐	白飯	2碗
	蔬菜	4安士
	雞脾	1隻
	甜豆奶	1杯
下午茶	橙汁	1杯
	方包	2片
	果占	3茶匙
晚餐	白飯	2碗
	肉餅	3安士
	蔬菜	4安士
	蘋果	1個
	紅豆沙	1碗

下列食物各含10克碳水化合物，運動員可自由組合至目標份量 (每日每公斤體重9-10克碳水化合物) :

麥皮 (熟)	1/3杯
意粉 (熟)	1/3杯
飯	1/5杯
粥	1/2碗
芝麻梳打餅乾	2塊
方包	1/2片
粟米片	1/2杯
粟米	1/3條
紅蘿蔔 (熟)	3/4杯
焗薯	1個 (雞蛋大小)
茄汁豆	4湯匙
蘋果或雪梨或橙	1個 (細)
奇異果	1個
香蕉	1/2隻
提子	10粒
罐頭水果	1/3杯
橙汁	1/2杯
鮮奶或豆漿	1杯
乳酪	150克
好立克粉	15克
汽水	1/2杯

參考資料:

1. Williams, C., 2007. Carbohydrate as an energy source for sport and exercise. In D. MacLaren, ed. *Advances in sport and exercise science series: nutrition and sport*. Liverpool: Churchill Livingstone Elsevier. Ch. 3
2. Burke, L. & Deakin, V., 2006. *Clinical sports nutrition*. 3rd ed. Australia: McGraw-Hill.

以上資料由運動員及科研事務科轄下的運動營養部提供，只供參考。

歡迎轉載以上資料，惟事先得本院許可；轉載時亦須鳴謝本院。

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