A RACE NUTRITION GUIDE FOR ENDURANCE ATHLETES

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INTRODUCTION

Race nutrition is one of the most essential elements of any endurance race. According to the former medical directors of one of the world's largest triathlon series: "poor race nutrition accounts for far more poor performances than lack of training, injury, mechanical failure or poor mental preparation". Despite this, race nutrition remains little more than an afterthought for many athletes.

For some, understanding the principles outlined here may seem like too much work. Trust me, it isn't. Chances are that if you're preparing to race a long-distance event, you've invested hundreds, possibly thousands of hours getting your body ready for this event. Spending an hour or two over the next few weeks improving your understanding of what works and what doesn't work in terms of race nutrition is going to boost your performance far more than spending that time training.

To make it as easy as possible to understand the various elements of a complete race nutrition program, I've broken down race nutrition into three key areas: fluid needs, energy needs, electrolyte needs. Because each element of your nutrition program builds on the others, try to make sure you understand the basic concepts discussed in one section of the guidebook before proceeding to the nest section.

So sit down, grab a pencil and calculator and spend a little bit of time figuring out your own unique race nutrition needs. Trust me, it will be time well spent!

SECTION 1: FLUID NEEDS

Section one of this guidebook is the longest and most complex. There's a good reason for that: hydration is the single most important element of any race nutrition plan. Be sure you understand the concepts outlined in this section before moving on to the subsequent sections.

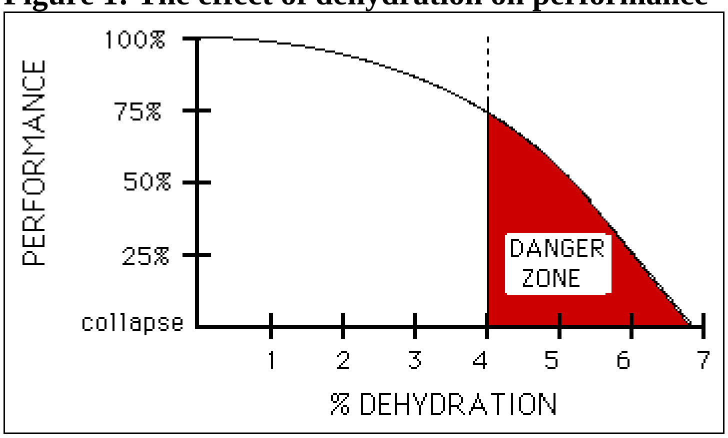
Part 1: The Importance of Hydration

The first and most essential part of any race nutrition plan is hydration. Maintaining optimal hydration is crucial for peak performance, and even "slight" decreases in hydration can affect performances. Even worse, more severe decreases in hydration can not only affect performance, they can jeopardize your health.

Key Concept #1: At low levels dehydration can affect your performance, at higher levels; it can affect your health.

Levels of dehydration are typically measured as a percentage of body weight. For example, in a 75 kg individual, a 1% level of dehydration would be 0.75 kg (or 750 grams). As we can see from figure 1, dehydration beyond the 4% range quickly leads to significant problems with performance and can even be medically dangerous.

Figure 1: The effect of dehydration on performance



The solution might appear simple- drink enough fluids in your race that you can't possibly become dehydrated. Unfortunately, drinking too much can be just as dangerous as not drinking enough.

In the past, athletes have often been so concerned about dehydration that they actually became too conscientious about drinking enough. However, over the past few years there has been growing evidence that over-hydration can be just as risky as dehydration (1,2)

Key Concept #2: Overhydration can affect performance and health as much as dehydration.

The reason over-hydration is dangerous is that drinking too much fluid can lead to an over-dilution of sodium in your bloodstream (a condition known as "hyponatremia"). When you sweat, you lose both fluid and sodium (you lose other electrolytes too, but sodium is the most important). If you replace your fluid (sweat) losses hour after hour with fluid containing little or no sodium, eventually the sodium in your bloodstream becomes too dilute. Hyponatremia can lead to serious medical illness (3-5) or even death (as occurred to a 28-year old woman who died of hyponatremia after completing the 2002 Boston Marathon) (1). In a study of 2002 Boston Marathon runners (1), 13 percent had hyponatremia at the finish and 0.6 percent had critical hyponatremia. This study also found several factors that were associated with an athlete's risk for developing hyponatremia (1):

Table 1: Risk Factors for Developing Hyponatremia
Substantial weight gain over the duration of the event
Over-consumption of fluids
Slower finishing times
Female sex
Lower Body Mass Index

Part 2: Calculating Maximum Fluid Requirements

The single best way for athletes to gauge how well their hydration plan is working is to sporadically weigh themselves immediately before and after races or workouts (1).

Key Concept #3: By weighing themselves immediately before and after races or workouts, athletes can get an accurate assessment of their unique individual fluid needs.

Coaches and sport physiologists call this "the fluid balance test" and use these periodic weigh-ins before and after workouts is an easy way to help athletes gauge their ***individual*** **fluid requirements**.

To use the fluid balance test properly, the first thing that must be understood is that *one litre of water weighs one kilogram*. Therefore, we can convert weight loss (in kg) into fluid loss (in litres). If we calculate how much weight (in kg) an athlete loses per hour and then replace the identical amount of fluid (in litres) then we are meeting that athlete's ***individual*** **maximum fluid requirement**.

At its simplest, the fluid balance test works like this: assume an athlete is ideally hydrated at the beginning of a workout, and we give them no fluid during the workout. The difference in weight from the beginning of the workout to the end of the workout represents the amount of dehydration. There are obviously a few problems with this basic fluid balance test. First, it assumes that all the weight you lose in a workout is due to fluid loss. In fact, this is not that big a problem. It is true that a small portion of the weight lost during the workout will come from non-fluid losses (like weight loss from burned body fat and body glycogen). However, fat glycogen and other non-fluids only account for 5% or less of the weight lost during a workout.

The second problem with this basic fluid balance test described above is that it doesn't allow athletes to drink and eat as the normally would in a workout. That is why most coaches and physiologists use a slightly more sophisticated fluid balance test (described in more detail later in this section of the guidebook) that allows athletes to also factors in the fluid consumed during the workout.

Key Concept #4: The fluid balance test tells us how much fluid an athlete loses per hour. If we know how much weight an athletes loses per hour, then replacing this amount represents that athlete's maximum fluid requirement

Even the best fluid balance test does have some limitations. One of these is that fluid requirements obviously vary with temperature, level of exertion, type of exercise etc. Therefore, an accurate assessment of your fluid needs requires that you try and make the conditions of your fluid balance test as similar as possible to the conditions of your race. Since some elements of race day (such as the weather) are impossible to predict, it is best for an individual to repeat the fluid balance under a variety of conditions. After you have done the test a few times, you will have a much greater appreciation for how your fluid needs change in response to different temperatures, humidity, levels of exertion etc. This knowledge can be indispensable on race day when you are trying to gauge how much to drink.

Another limitation with this test is that all the fluid balance equations below lose their accuracy if you really over-hydrate during the workout. The easiest way to determine if you've over-hydrated in a workout is that you will weigh more after your workout than you did at the beginning. If you find this is the case, do the fluid balance test again another day and decrease your fluid intake

Part 3: The Fluid Balance Test

Instructions for the Fluid Balance Test:

- Weigh yourself (in kg) in dry clothes with an empty bladder before a long workout.
  Record this number in **A: pre-workout weight (in kg)**

- Keep track of your fluid intake (in liters) during the run and/or bike (Remember: a regular water bottle holds about 500mL or 0.5 liters. A large water bottle hold about 750ml or 0.750 litres).
  Record this number in **B: fluids volume ingested (in litres)**

- After your workout, towel-off excess sweat and weigh yourself in the **same** dry clothes as before.
  Record this number in **C: pre-workout weight (in kg)**

- Keep track of the duration of the workout.
  Record this number in **E: length of workout (in hours)**

The Fluid Balance Test

- To calculate your **maximum hourly fluid needs**, you will need the following numbers:

A:	________________	pre-workout weight (in kg)
B:	________________	fluids volume ingested (in litres)
C:	________________	post workout weight (in kg)
D:	________________	**maximum total fluid needs** (calculated below)
E:	________________	length of workout (in hours)
F:	________________	**maximum hourly fluid needs** (calculated below)

- First, use this equation to calculate your *total* fluid need:

Equation #1 (Maximum Total Fluid Needs):
A + B - C =
D: ______________ Maximum Total Fluid Needs (in litres)

- Then, use this equation to calculate your maximum *hourly* fluid needs:

Equation #2 (Maximum Hourly Fluid Needs):
D/E = ________ Maximum Hourly Fluid Needs (in litres/hour)

Example:

A:	Pre-workout weight:	65.2 kg
B:	Fluids ingested:	2.2 litres
C:	Post workout weight:	63.8 kg
D:	Maximum total fluid needs:	
	65.2 + 2.2 – 63.8=	3.6 litres
E:	Length of workout	4 hours 30 min (i.e. 4.5 hours)
F:	Maximum Hourly Fluid Needs	
	3.6/4.5= 0.8 litres/ hour	(800ml/ hour)

Part 4: Using the Fluid Balance Test

Equation #2 above gives you your *maximum* hourly fluid intake, which is based on how much fluid your body loses each hour. As discussed in the previous section, athletes should not try and drink more than their maximum hourly fluid intake, as this can lead to overhydration and hyponatremia. However, especially for shorter races, you may need to actually drink quite a bit less than your maximum hourly fluid intake.

In races lasting less than 3 or 4 hours, staying 100% hydrated may not be possible, or even desirable- the pace of the race is simply too intense and your gut probably cannot handle drinking enough fluid to achieve maximum hourly fluid intake. As a rule: the harder the pace, the more difficulty your g.i. system has absorbing fluid. The good news for shorter distance athletes is that even if they drink absolutely nothing during their race, it still takes several hours of intense sweating to lose enough fluid to develop severe dehydration.

For these reasons, replacing fluid losses in shorter races is not usually a big concern. However, in longer distance races, dehydration is huge concern. Studies of long-distance athletes indicate they often lose 3-5% or more of their body weight over a race (6,7). Most of this weight loss is due to dehydration. Take a moment to go back and review figure 1 in the previous section. As you can see, many athletes finish long-distance races with levels of dehydration that may affect their health, and almost certainly affects their performance.

It is probably unrealistic to expect many long-distance athletes to maintain 100% hydration. At the same time, those who can reduce their level of dehydration in the race to just 2% will have a significant performance advantage compared with more dehydrated competitors.

Key Concept #5: Athletes need to ensure that they do not drink too much fluid (which can lead to g.i. distress and/ or hyponatremia). They also need to ensure they do not drink too little fluid (which can lead to dehydration). Most athletes should endeavour to consume enough fluid to keep their level of dehydration to 2% or less. This amount of fluid represents the athlete's "ideal hourly fluid intake".

The three factors that are the in terms of determining your ideal hourly fluid intake are:

1. Pre-race weight
2. Predicted finish time (of your race or workout)

3. Hourly rate of Fluid Loss (which, as we know, is the same as our maximum hourly fluid needs, that we have already calculated in Equation #2 above)

Cavacuiti's Method for Determining Ideal Hourly Fluid Intake:

A: Pre-race weight (in kg) ____________________
B: Predicted finish time ____________________
(Chose a finish time that is reasonable, not ideal or 'best-case scenario'. Record a predicted finish time of 4 hours, 30 min as 4.5, 4 hours 15 minutes as 4.25 etc.)
C: Hourly rate of Fluid Loss (in ml) ____________________

Ideal hourly fluid intake (in ml/hr)= C – (A x 20/B)

Example:
An athlete's hourly fluid loss is 800 ml/ hour. His pre-race weight is 65 kg. On an ideal day, he might do a ½ ironman in just over 4.5 hours. However, a more reasonable estimate is closer to 5 hours.

Ideal hourly fluid intake = 800 – (65 x 20/5)
= 800 – (65 x 4)
= 800 – 260
= 540 ml/ hour

Key Concept #6: If you remember absolutely nothing else from this guidebook, remember the number (in ml/hour) you have calculated using Cavacuiti's method for Determining Ideal Hourly Fluid Intake. As long as you consume this amount of fluid throughout your race, then your race is unlikely to be stopped by dehydration or overhydration.

SECTION 2: ENERGY NEEDS

In shorter races, the calories we ingest *during* the race account for just a small fraction of the calories we burn in the race. The vast majority of our energy comes from the calories we ingested *before* the race, which are now stored as fat and glycogen. In shorter races, a basic understanding of hydration is often all we need. We may not finish quite as well as we would with optimal nutrition, but it's still very likely we'll finish**. In longer races, we can't just rely on our internal energy stores, because much of the energy we will need comes from the calories we ingest *during* the race.** In fact, the amount of carbohydrate intake, especially later in the race, has been shown to predict Ironman race performance (8).

Unfortunately, taking in calories (especially lots of calories) is much trickier than you might think. The problem is, our gastro-intestinal (g.i.) system can only handle a certain number of calories per hour. Too many calories lead to g.i. problems. Studies show that **30-50% of marathon runners and long-distance triathletes experience g.i. problems** (9-11), and that high calorie loads are a leading culprit.

Calorie intake in an endurance event is precarious balance between too few calories, which causes diminished performance or too many calories, which causes g.i. problems. There are several methods long-distance athletes can chose from to calculate their hourly calorie needs:

Table 2: Three Methods to Calculate Hourly Calorie Intake	
Method #1	**Do what other long-distance athletes do.** A recent study of caloric intake at an Ironman showed that males ingested an average of 3,940 calories and females ingested an average of 3,115 calories(7). Assuming an average finishing time of 14 hours for men and 15 hours for women, this works out to an average of 280 calories per hour for men, and 210 calories per hour for women.
Method #2	**The 4 cal/kg/hr rule.** This method bases your caloric intake on your weight. Several authorities recommend consuming carbohydrates during exercise at a rate of about 3-4 calories of carbohydrate per one kg of body weight per hour. Using a 65 kg athlete as an example, if she wants to consume 4 calories/kg/hr, then she should be consuming 260 calories per hour (65 x 4 =260).
Method #3	**Cavacuiti's Method for Determining Ideal Calorie Intake (The 1/3 Rule).** The 1/3 Rule states that athletes should be ingesting approximately *one* calorie for every *three* mL of fluid they consume. Of the three methods listed, this is the only one that takes into account one of the most important (and misunderstood) elements of race nutrition- the number of calories your gut can handle is proportional to the amount of fluid you consume. The more fluids you are drinking, the more calories your gut can handle.

Cavacuiti's Method for Determining Ideal Calorie Intake (The 1/3 Rule)

Athletes should aim to ingest approximately *one* calorie for every *three* mL of fluid they consume during a race.

In simple terms, if the food and fluid in the stomach has too many calories, the stomach delays delivering its contents to the intestine. What is surprising is that it's not the *absolute* number of calories in the stomach that seems to matter; it is the *concentration* of calories relative to fluid (12).

Our minimum hourly intake can be calculated using the fluid balance test (see the previous section). Most sports nutrition products have their calorie content on their packaging. For those products that don't list calorie content, athletes can use **Table 3** to get a good approximation of the calorie content of their race nutrition.

Table 3: Number of Calories from Various Energy Sources	
1 gram of fat:	produces 9 Calories
1 gram of carbohydrates:	produces 4 Calories
1 gram of protein:	produces 4 Calories

SECTION 3: MINERAL/ ELECTROLYTE NEEDS

Table 4: Minerals and Electrolytes in Exercise						
Mineral/ Electrolyte	RDA (mg)	Typical Intake (mg)	Body Content (mg/75kg)	Sweat Content (mg/L)	Sweating can lead to deficiency?	Needs replacing during a race?
Sodium	<2,400	4,000	80,000	1,500	Yes	Yes
Potassium	3,500	4,000	250,000	150	No	No
Chloride	750	6,000	115,000	2,500	No	Yes
Zinc	15	15	2,000	1	Maybe	No
Magnesium	300	500	25,000	100	No	No
Iron	14	20	4,500	0.3	Maybe	No
Calcium	800	800	1,500,000	25	Maybe	Maybe

Sodium

Sodium is the single most important mineral/ electrolyte from an endurance perspective and (along with chloride) is one of the only elements that is lost in sufficient quantities in sweat that it actually needs replacing **during** exercise. Low sodium (also known as hyponatremia) can lead to fatigue, weakness and muscle cramps. In more severe cases, it can lead to seizures and even death. Most cases of exercise induced hyponatremia result from an over-consumption of water combined with an under-consumption of sodium.

In order for athletes to determine how much sodium they should replace, it is important to understand the difference between “sodium” and “salt”. Sodium is single element with the chemical name “Na”. On the other hand, “salt” (such as common table salt) is a molecule made up of two elements- Sodium (Na) and Chloride(Cl). Salt has the chemical name SodiumChloride (NaCl).

Key Concept #8: Sodium is single element with the chemical name “Na”. “Salt” is a molecule made up of two elements- Sodium (Na) and Chloride(Cl).

Many of the articles on nutrition talk about replacing a given amount of “Salt” (Sodium Chloride). Rehrer, for example, suggests replacing approximately 2-3g of salt (NaCl) per litre of fluid ingested during exercise (13). However, most nutrition products report only the number of mg of Sodium (Na) they contain. Most products on the market do not report the weight of NaCl or Cl.. As we have just learned “Salt” and “Sodium” are not the same thing. In fact, about 60% of the weight of Salt comes from Chloride (the other 40% comes from sodium).

Key Concept #9: 40% of the weight of "Salt" (NaCl) comes from Sodium (Na) and 60% comes from Chloride (Cl).

To summarize what we know so far: most authorities recommend replacing about 2.5g of salt per litre of fluid ingested during a race and 40% of the weight of salt comes from sodium. This means that the ideal intake of sodium during a race is about 1g of sodium (i.e. 2.5g of SodiumChloride) for every litre of fluid.

Cavacuiti's Method for Determining Ideal Sodium Intake (The "1 to 1 Ratio Rule")

Athletes should aim to ingest approximately *one* mg of sodium for every *one* mL of fluid they consume during a race.

Potassium

Potassium is stored mainly inside cells of the body. A significant proportion of an athlete's total body potassium is stored in muscle cells along with glycogen and water. When glycogen is released into the blood stream to supply the energy needs of a long-distance race, the potassium and water are also released into the blood stream.

This means it is important to ensure that your carbo-loading in the final phase of taper not only loads your muscles with carbs (which your body turns into glycogen) but also loads your body with potassium and water.

Potassium is found in many fruits and vegetables and potassium supplements are not usually necessary to meet the potassium needs of athletes. Good dietary sources of potassium include citrus fruits, bananas, and tomatoes.

Chloride

Chloride is the "overlooked element" of endurance athletics. Because sodium is so important to the body, we often forget that sodium generally enters and leaves the body not as sodium, but rather as salt (aka sodium *chloride*).

Low serum chloride concentrations (hypochloremia) can occur as a result of heavy losses of chloride (through sweat, vomiting and/ or diarrhoea) or from an excessive dilution of chloride from over-hydration. Symptoms include muscle weakness, loss of appetite, irritability, and lethargy.

Because low chloride tends to develop later in races than low sodium and is usually less severe than low sodium, most of the electrolyte research has focussed on sodium replacement. Indeed, many of the salt tablets on the market don't even list the weight chloride they contain (a testament to how little the world of endurance-athletics seems to care about chloride).

The good news is that, practically speaking, as long as athletes are ingesting enough sodium chloride to meet their sodium needs, then chances are they're also meeting their chloride needs.

Zinc

The RDA (Recommended Daily Allowance) for zinc is 15mg per day and most North American diets contain approximately this amount of zinc. Since every litre of sweat contains an mg of zinc, it is possible that prolonged daily exercise could leave to a mild zinc deficiency. A daily multivitamin supplement would more than offset zinc losses through sweat.

Magnesium

Most healthy North American diets contain more than enough magnesium to meet the RDA. Good sources of magnesium include green, leafy vegetables such as spinach, cabbage, lettuce, broccoli. Athletes should be cautious about replacing too much magnesium (especially in the form of supplements) as magnesium is a well known laxative and aggressive magnesium replacement can therefore lead to diarrhoea. No studies have shown improved performance with magnesium supplements.

Iron

The amount of iron in sweat is not likely to be enough to cause iron deficiency. However, because iron deficiency is a relatively common problem (particularly in women) and because iron deficiency can lead to health problems such as anemia, it is reasonable for athletes to supplement their daily intake with a multivitamin, especially on heavy workout days.

Calcium

While the intake of calcium is about 800mg/ day, only about 25% of this (about 200mg/ day) is actually absorbed. A workout that results in 4 litres sweat could mean losing 100mg of calcium (about half of what the body absorbs that day). Calcium deficiency can result in health problems such as osteoporosis. Therefore, it is reasonable for athletes to supplement their daily intake with a multivitamin, especially on heavy workout days.

There is also some anecdotal evidence that the use of one or two calcium tablet (such as Tums) over the course of a race may reduce the risk of muscle cramps. However, no studies have thus far have shown improved performance with calcium supplementation.

SECTION 4: EXAMPLES

Below are some real world examples applying these rules. **Please note:** the products and nutrition strategies below should be viewed as *examples*, rather than specific recommendations. All the products below work well, but so do many others on the market.

As long as your nutrition strategy meets the rules and guidelines above, it is far more important to choose a product that tastes good to you than it is to use a particular brand. Aside from how good a product tastes and how well your stomach tolerates a product, one other major consideration is what nutrition products will be at the aid stations at your goal race. It is always a very good idea to train with the same products you plan to race with, so unless you plan to carry all your own nutrition and fluid, find out what will be at the aid stations.

EXAMPLE 1

Q: A 60 kg female athlete is hoping to do a 6 hour half-ironman. She does a fluid balance test on a long hot 5 and ¼ hour training day. During the workout she drinks 600mL per hour. At the end of the workout she weighs 58.2 kg. How much should she consume during her race in terms of fluid, calories and sodium?

A: **She should be consuming 740 ml of fluid, 250 calories and 750 mg of sodium each hour during her race.**

Explanation:
In terms of fluids: Using the fluid balance equations: A=60kg, B=0.6x5.25=3.15litres, C= 58.2kg, D=0.942ml/hr. Thus her ideal intake is 942-(60 x 20/6). **Therefore, her ideal intake is 742 mL per hour.**

In terms of calories: According to the 1/3 rule, if her fluid intake is approximately 750 mL/hr, she should be able to easily consume 1 calorie for every 3 mL of water. **Therefore, her ideal calorie intake is 250 calories per hour.**

In terms of sodium: According to the "one to one ratio rule", if she consumes 750 mL of fluid per hour, **she should consume 750 mg of sodium per hour.** Interestingly, authors who have studied female athletes during prolonged exercise recommend sodium intakes of at least 680 mg/h (14). A number very similar to what we have calculated for this woman.

EXAMPLE 2:

Q: An athlete determines his ideal hourly intake for a 6 hour bike race is 750mL per hour. His preferred drink is eLoad ™ with three Zone Cap ™ salt/ energy tablets added to every 750mL water bottle. He'd like to know if he should be consuming additional calories (he likes chocolate flavour ClifShot ™ gels) or extra sodium during his race.

A: One ClifShot per hour will put this athlete very close to his ideal fluid, calorie and sodium intake.

Explanation:
In terms of calories: Based on eLoad's packaging, it has 108 calories per 500 ml. According to Zone Cap's packaging, each tablet contains 0.2 grams of carbohydrate (about 8 calories). If this athlete consumes 750mL of eLoad per hour, with 3 zone caps per hour, this means he is getting 162 calories from eLoad and 24 calories from Zone Caps (186 calories in total). This is about 80 calories less than he needs (since according to the one-third rule, he needs 266 calories per hour). A chocolate ClifShot gel has 100 calories. Assuming about 15-20% of the get stays in the package, he will get about 80-85 calories from one gel per hour, giving him almost the perfect number of calories he needs.

In terms of sodium: Based on eLoad's packaging, it has 370mg of sodium per 500 ml. Therefore if he drinks 750 mL per hour that is 555mg of sodium. In addition each Zone Cap contains 51mg of sodium. Three ZoneCaps per hour gives him a total of 153mg of sodium per hour from Zone Caps. Each ClifShot gel contains 40 mg of sodium mg of sodium. 750mL of ELoad, 3 Zone Caps and one ClifShot per hour will provide 748 mg of sodium. Which is very close to his ideal sodium intake.

EXAMPLE 3:

Q: A female athlete competes in half marathons and finishes in about two hours. Her ideal fluid intake for her race is 450mL per hour. In training, she consumes about 450 ml of water per hour and "one or two gels" over the course of a two hour workout. This nutrition plan is working well for her. She is not worried about sodium and wants to know when and how many PowerGels™ she can consume in her race?

A: This athlete can probably consume 1 PowerGels at about 45 minutes of racing and a second at about 90minutes of racing.

Explanation:
In terms of calories: This athlete drinks 450 calories per hour. Therefore, by 45 minutes of racing this person will have ingested about 340mL. The one third rule states this athlete can therefore safely consume about 113 calories by about 45 minutes into her race. Based on PowerGel's packaging, it has 112 cal per gel

In terms of sodium: The fact that her race nutrition does not contain many electrolytes is not likely a problem from a sodium depletion perspective. Her race is probably short enough that she will not lose enough electrolytes through sweat to worry about hyponatremia and the need for sodium replacement. However, she should be advised that sodium can also help with fluid absorption and digestion. If gut problems are issues for this athlete, she should consider adding sodium (following the one-to-one rule) to her race nutrition plan.

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