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Nutritional Intake Predicts Performance in an Ironman Triathlon

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Finish time for 59 triathletes in an Ironman triathlon correlated highly with rates of carbohydrate and water intake (r = -0.65 and -0.51). Triathletes with below average intakes of carbohydrate and water can therefore expect to achieve worthwhile reductions in finish time of around 5% from moderate increases in intake.

KEYWORDS: carbohydrate, diet, sodium, hyponatremia, ultra-endurance

Introduction

Competing in ultra-endurance events—those lasting more than 2-3 hours—probably puts more demand on the fluid and energy balance of the body than any other form of exercise, yet research on the nutritional intake of athletes during such events has not addressed the question of relationships between intakes and performance (Peters et al., 1986; Applegate et al., 1989; Saris, 1990). The aim of the present study was describe these relationships for one of the most popular of the ultra-endurance events, the Ironman triathlon.

Methods

The event consisted of an inner-harbor ocean swim (3.8 km), a bike ride (180 km) and a marathon run (42.2 km). Air temperature ranged from 18 to 27°C, humidity was approximately 65%, winds were light, and the sky was partly cloudy throughout the event.

Two researchers interviewed as many athletes as possible soon after (<1 h) the athletes crossed the finish line. In this sample of 59 triathletes (age 33 ± 7 y, mean ± SD), self-reported body mass was 74 ± 7 kg for the 52 males and 56 ± 3 kg for the 7 females. Finish times for these subjects (females, 11.7 ± 0.8 h; males, 10.7 ± 1.1 h) were taken from the official results obtained from the organizers of the event.

At check-in time prior to the race, we had primed athletes for the dietary recall by showing them examples of the detail of food and fluid consumed in the hour preceding the event, in the transitions between phases, and in the first and second half of the cycle and run phases. Total intakes of energy, carbohydrate, protein, fat, sodium, and water from all sources were derived by standard dietary analysis. Our institutional ethics committee approved all procedures.

We expressed relationships between finish time and other variables as Pearson correlations. A multiple linear regression provided estimates of the gain in time corresponding to combined consumption of extra carbohydrate, water, and sodium. We also used standardized regression coefficients of log-transformed variables to estimate the percent change in performance associated with a moderate change (one standard deviation) in intake of a particular nutrient.

Results and Discussion

Food consumed during the event was mainly that provided at the aid stations by the race organizers: bananas, oranges, high-carbohydrate sports bars, and sports drinks containing carbohydrate and electrolytes. Proportions (%) of macronutrients by energy were: carbohydrate, 94 ± 7; fat, 3 ± 5; protein, 2 ± 3.

Table 1 summarizes rates of nutritional intake during the event, and their correlations with finish time. The highest correlations were observed for rates of intake of carbohydrate (or energy) and water; at either end of the likely range the highest of these correlations represent effects that are moderate to large. For example, the correlation of finish time with the rate of carbohydrate intake relative to body mass could be from -0.74 to -0.39, which represent improvements in performance of between 7.2% and 3.6% for an increase in carbohydrate intake of 0.40 $g\cdot kg^{-1}\cdot h^{-1}$ (a change of 1.0 standard deviation). The most likely gain in performance is about 5%, or about half an hour over 10 hours.

Table 1: Rates of water, energy, carbohydrate and sodium intakes of 59 Ironman triathletes during the event, and correlations of the intakes with finish time.

	Intake[a]	Correlation[b] with finish time
Carbohydrate ($g\cdot kg^{-1}\cdot h^{-1}$)	0.96 ± 0.40	-0.59 (-0.74 to -0.39)
Energy ($kJ\cdot kg^{-1}\cdot h^{-1}$)	16 ± 7	-0.56 (-0.71 to -0.35)
Water ($ml\cdot kg^{-1}\cdot h^{-1}$)	12 ± 5	-0.45 (-0.63 to -0.22)
Sodium ($mg\cdot kg^{-1}\cdot h^{-1}$)	4.0 ± 4.8	-0.12 (-0.36 to 0.14)

[a]Mean ± standard deviation
[b]Observed value of Pearson correlation between dietary variable and log-transformed finish time; 95% likely range of true correlation in parentheses.

Athletes apparently need high intakes of carbohydrate and water to perform well in the Ironman triathlon, for the obvious reason that the body's stores of these substances are sufficient only for several hours of high-intensity exercise (Applegate et al., 1989). However, multiple linear regression showed that there was only a trivial additive effect of increasing both water and carbohydrate intake: separately increases in rates of carbohydrate and water intakes of 0.40 $g\cdot kg^{-1}\cdot h^{-1}$ and 5 $ml\cdot kg^{-1}\cdot h^{-1}$ were associated with reductions in finish time of 6.0% and 4.6% respectively, but together the reduction was only 6.2%. The obvious interpretation here is that most athletes link their food and fluid intake; these two variables were indeed highly correlated (r = 0.68).

The slight beneficial effect of sodium intake considered on its own became a slight negative effect in the multiple linear regression. We expected sodium intake to show a stronger relationship with performance, even in the multiple linear regression, because a reasonable proportion of Ironman triathletes become hyponatremic (Speedy et al., 1999).

Evidently the effects of hyponatremia on performance are not sufficiently marked for sodium intake to have a noticeable effect, at least not in our study.

The strong negative correlations between performance time and rates of intake of water, energy and carbohydrate may arise to some extent because the rates are calculated by dividing the total intake by the finish time. On the other hand, using the total intake as the predictor variable could tend to underestimate the strength of any negative effect of intake on finish time, because the slower athletes had more time to consume food and drink during the event, and so could end up consuming more in total. The fact that substantial negative correlations were obtained for total intakes (data not shown) gives reassurance that there is a true underlying effect of intake on performance.

The observed correlations are consistent with the results of the many experimental studies showing enhancement of endurance performance when athletes supplement with water or sports drinks during exercise (Noakes, 1993). Ours is the first study to show that differences in intakes between athletes in a real competition account for substantial differences in performance, but we must be cautious about recommending an increase in the intake of water and energy or carbohydrate for all athletes. The average athlete in our study was already consuming carbohydrate at the maximum rate that is thought to be absorbable during high-intensity endurance exercise (about 1 $g \cdot min^{-1}$) (Hawley et al., 1992), and although sweat rates of 2-3 $L \cdot h^{-1}$ are possible in extreme conditions (Terrados and Maughan, 1995), the average rate of water intake observed here may have been similar to the sweat rate for the relatively cool conditions in which the event was performed. Only those athletes with below average intakes might therefore expect to enhance their performance by increasing their intakes. Faster athletes may also have attained higher intakes because they were more aware of the need to supplement, but they may not have obtained any benefit from the extra intake.

In conclusion, Ironman triathletes who increase their below-average consumption of food and drinks in an event can expect to enhance performance by at least a few percent. These findings should apply to a substantial proportion of athletes in all ultra-endurance events lasting 8-15 h.

Editor's note (8 Sept 2001): Prof Tim Noakes has asked me to add a note to emphasize that only randomized controlled trials can establish clearly the effect of increased food and fluid intake on competitive performance.

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