Nutritional Preparation for an Ultra-Endurance Swimmer: A Case Report

Case Study

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Abstract

Introduction: Nutritional considerations and metabolic determinates for ultra-endurance events continue to evolve with the increasing popularity of events. This case study assessed the nutritional requirements required of 30-year-old male ultra-endurance athlete to successfully complete an endurance open-water swim.

Methods: Dietary intake in preparation for the event was assessed, estimated caloric needs, and a nutritional analysis was performed on the athlete to determine nutritional intake that was required to successfully complete the endurance swim event. The athlete was monitored for 24.3 miles (Ontario, Canada to Northeast, Pennsylvania, United States). Day of nutritional changes were observed, and body composition was assessed pre- and post-event.

Results: The swimmer was monitored for 11 hours, 28 minutes and 5 seconds. Determination of athletes' potential metabolic energy would shape the energy cost to complete the endurance event. Modifications prior to the ultra-endurance swim event met the athlete's energy requirement for training and the energy reserve needed for the endurance swim event.

Conclusions: The addition of calories and nutritional modifications prior to the ultra-endurance swim event met the athlete's energy requirement for training and the energy reserve needed for the endurance swim event. This case study highlights the importance of providing nutritional support for ultra-endurance athletes and the difficulty in predicting energy expenditure for such an event.

Key Words: Nutrition, Caloric expenditures, Swimming efficiency

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Introduction

Ultra-endurance competitions and athletes typically are active for more than six hours in their event, which imposes high demands on the body.[1] Challenges include depletion of glycogen stores, avoiding hypoglycemia, dehydration, and increased oxidative stress.[1,2] To avoid potential energy deficits that incur during competition, proper nutrition is required before and during competition to achieve an optimal performance which includes adequate pre-event caloric and nutritional intake and options for reloading during the duration of the event.

The process to prepare for an ultra-endurance event requires the application of physiological techniques and principles to formulate a nutritional plan for the athlete to perform maximally. In addition, the athlete's physiology and personal goals are also considered when a nutritional plan of action is formulated. For this case study, researchers used physiological techniques to determine an ultra-endurance swimmer's nutritional requirements required to successfully complete a long-distance open-water swim. In addition, day-of observations and post-event assessments of body composition were conducted. The aim of the case report was to identify and evaluate the athlete's nutritional determinants and provide dietary feedback to meet the athlete's goals for the successful completion of the endurance event.

Methods

Research Plan

The athlete's swim was sanctioned by the World Open Water Swim Association (WOWSA) and locally by the Lake Erie Open Water Swim Association (LEOWSA), and the research plan was presented to both organizations. According to LEOWSA, the researchers were not allowed direct interaction with the athlete in the water. As such, all nutritional preparations were supplied to the athlete via kayak in the water. For this reason, fluid/supplement intake during the swim were only observed and estimated. For this study, initial assessments were made seven weeks prior to the event, which included dietary assessment, body composition, and cardiovascular testing.

Presentation of Athlete

The participant was a 30-year-old male ultra-endurance athlete who had been swimming for over 10 years competitively. He was referred to the researchers to discuss his current diet, training nutrition prior to the event, nutritional options during the swim event, baseline body composition, and aerobic capacity. The subject provided informed consent to take part in the case study, as well as permitting use of his personal data from the laboratory tests and his swim. The study was approved by the Institutional Review Board at Gannon University.

Determinants of Performance

In ultra-endurance swimming, energy expenditure varies greatly from individual to individual. Measures of stroke rate, heart rate, and stroke efficiency (economy of motion) are key variables to determine the athletes' needs and potential outcomes.[3] Previous research in ultra-endurance swimming has yielded a foundational knowledge base encompassing the energy cost of swimming[4], efficiencies and mechanics of swimming[3,5,6], the physiological characteristics of open water swimmers[7], and the fluid and nutritional preparation[8,9]. In addition, swimming research poses many challenges due to swimmer technical mastery, environment of open water swimming, and extraneous factors (age, sex, training level, nutritional support…). Using the knowledge and established determinants of swimming performance helps to serve as a framework for the researchers to develop the methods for this case report.

Pre-Competition Diet Assessment

The athlete completed a dietary food log for one week that included foods eaten, portion size, snacks, supplements, and water consumption. The athlete expressed that a goal was to add 5-10 pounds before the event and maintain an appropriate energy reserve for the swim. In addition, the athlete expressed the desire to increase his body fat percentage to increase buoyancy and body insulation for the swim event.

To determine calories needed to meet his goals, basal metabolic rate (BMR) of the athlete was first calculated using the Katch-McArdle (1996) equation, which is commonly used in athletic populations with high muscle mass.[10]

$$\text{LBM} = (0.407 \times 77.1\text{kg}) + (0.267 \times 180.34\text{cm}) - 19.2 = 60.33$$

$$\text{BMR} = 370 + (21.6 \times 60.33) = 1673.12 \text{ calories}$$

Lean body mass (LBM) was determined prior to competition (see also Pre-Competition Body Composition Assessment). LBM, in addition to fat free mass (FFM) from air-displacement plethysmography, provides an accurate prediction of basal metabolic rate.[11]

In addition, the American College of Sports Medicine Position Stand was consulted to determine nutrient ranges for the athlete.[12] Based on these assessments, it was determined that the athlete was deficient in total calories and carbohydrates. The athlete also reported that he was starting a two-a-day training program phase; no changes were suggested for protein and fat intake due to the increase in training. Calorie-rich, carbohydrate-dense meals and possibly adding mini meals or snacks were suggested. Nutritional intake and suggested modifications can be found in Table 1.

Table 1. Dietary assessment and recommendations.

Macronutrient Ranges	Athlete Self-Reported Intakes	Nutrient Recommendations	Suggested Changes
Total Calories	2,362 calories	3,140.24	+ 1278 calories
Carbohydrate 6-10g/kg	184 g	462.6 – 771.0g/kg	+ 587 g
Protein 1.6-1.7g/kg	158 g	123.36 – 131.07g/kg	No Change
Fat 25-30% total calories	114 g	87.2 – 104.2g	No Change

Pre-Competition Body Composition Assessment
Prior to competition, the athlete's height and weight were measured and were used to determine body mass index or BMI, where BMI = weight (kg)/height (m^2). In addition, body fat percentage was determined using air displacement plethysmography via the Bod Pod (COSMED USA, Inc., Concord, CA). Instrumentation accuracy of the Bod Pod is reported as ±1 to 3%, with an intraclass correlation coefficient (ICC) for reliability as 0.991. Pre-event metrics can be found in Table 2.

Pre-Competition Training
Liquid ingestion was the proposed method of reloading nutrients and hydration during training via high energy electrolyte drinks and gels. To add variety and increase calories and carbohydrate intake as mileage increased during training, the researchers suggested adding options such as applesauce, applesauce that contained oats, squeezable yogurt, and peanut butter to the athlete's training plan. The literature suggests increasing endogenous carbohydrate stores during ultra-endurance training so as to efficiently utilize muscle glycogen or liver-derived plasma glucose during exercise to establish a dietary carbohydrate goal of 10-12g/kg to support endogenous stores and reduce training fatigue.[13]

Day of Event Considerations
Refueling during the event was agreed upon to be liquid based, which was also in line with the restrictions imposed by LEOWSA. In addition, consuming carbohydrates in liquid form reduces gastrointestinal distress and eases indigestion during endurance events.[14] To optimize blood glucose oxidation and delay fatigue during the event, 30 to 70g of carbohydrates per hour or 0.2 to 0.6g/kg were recommended.[14,15] However, the athlete requested the following plan for the event day: one bottle of water, one bottle of mixed high energy electrolyte drink, and two gels, for a total of 135g per hour, which exceeded the recommended amount by 65 – 105g per hour, but was within a safe range for ultra-endurance swims.[13] The supplement bottle contained two scoops of High Energy Electrolyte Drink (HEED) supplement, one and half scoops of Perpetuem supplement, and two Hammer energy gels to be consumed every hour during the event, which contained the ratios of complex carbohydrates, protein, healthy fat that the participant had been using as part of his training package. The supplement bottle contained approximately 482.5 calories of potential nutrients for refueling. The researchers acknowledge that when athletes self-select their own supplements there are potential biases that can affect performance and outcomes. Some of the biases the researchers considered were the athlete's personal preferences, the anecdotal evidence for performance, and placebo effect. These biases are crucial to consider as the researchers were determining overall caloric needs for the event and interpreting probable consumption.

The researchers then estimated the calories that the athlete would utilize during the event. According to Koehler, a carbohydrate range of 60-90g consumed per hour would yield 240-360 calories per hour for a total of 2880-4320 calories spent during the 12-hour goal for the swim.[13] Therefore, the athlete's request for 135g per hour would yield 540 calories per hour and 6,480 calories for the 12 hours estimated swim.

A second estimate included an analysis of metabolic equivalents (METs) for swimming a 12-hour event. Research has shown that economical swimmers use minimal energy to maintain a consistent pace over time; thus, swimming economy will thereby equal energy cost.[4] Determining a moderate to steady pace in swimming is considered a physiologically strenuous activity or intensity.[16]

$$(6.0 \text{ MET} \times 77.1\text{kg} \times 3.5) / 200 = 8.10 \text{ cal/min}$$

Using MET values to determine energy expenditure in swimming can be challenging due to factors such as variability in swimming strokes, individual swimmer differences (age, gender, body weight…), swim efficiency, and water temperature and conditions. MET values are based on averages and can be translated to different populations with caution within the same activity. Therefore, a MET value of 6.0 (moderate pace for swimming) would yield 486 calories per hour of expenditure for 5832 calories for the 12-hour estimated swim. The researchers and athlete were pleased and acknowledged the ± 648 calories between the two estimations. This difference would account for consumption losses during the event or overages in activity time for the event.

Results
Event Day Outcomes and Observations

The athlete started the swim from Long Point Ontario, Canada at 7:14am. Heart rate (HR) was measured during the entire swim at 5-second intervals using the Polar RCX5 heart rate monitor (Polar, USA). Accuracy for the Polar heart rate monitors was found to be ± 1 bpm with an ICC of > 0.999. This allowed for collection of 8,252 HRs over the entire swim. His HR mean was 155.8 ± 8.9 beats/min for the entire swim, with a minimum HR of 129 beats/min and a maximum HR of 177 beats/min. Over the course of a 11+ hour swim, the subject spent 99% of the time between a HR of 133-170 beats/min (30% of the swim between 133-151 beats/min, 69% between 152-170 beats/min). This range was found to be between 52-79% of the swimmer's heart rate reserve (HRR).

During the swim, stroke count averages were also monitored at 11 different points during the crossing. Stroke efficiency was used as a key determinate of energy estimation and expenditure. Stroke rate was measured as the number of seconds required to complete one complete stroke cycle.[17] The swimmer averaged 58.3 strokes/minute during the swim (56 being the least amount and 61 being the highest total strokes/minute). This athlete's swimming economy was mostly maintained for a consistent pace and period, suggesting that he used minimal energy expenditure to complete the event effectively.[4] The reader is referred to a detailed description of the heart rate and total stroke count for this athlete and event.[18]

The consumed water and supplement bottles were brought back to the lead boat for reloading and returned to the athlete via the support kayak. It was estimated that the athlete consumed ¾ of the contents of the supplement bottles. Because the bottles initially exceeded the recommended amount of carbohydrate prior to the start of the event, the researchers concluded that consuming ¾ of the contents of the bottles would be enough carbohydrate required to complete the event. The athlete followed the planned protocol to refuel each hour until mile 9; four water bottles and four supplement bottles were recorded during this time. At this point, the athlete did not consume any more water from the bottle, stating that he was swallowing amounts of lake water. The athlete was only ingesting supplement bottles from here on (seven more were delivered). The researchers were unable to track his hydration levels as the water bottles were no longer delivered to the athlete.

At mile 10, the athlete reduced his hour-long breaks to 50 minutes. At mile 12, the athlete requested an additional half scoop of Perpetuem to be added to the supplement bottle, bringing the estimated calories to 534.25 per bottle. After mile 21, the athlete shortened the planned breaks to 45 minutes, which lasted until the end of the event, suggesting that fatigue may have been setting in. Ultimately, the researchers determined that the athlete consumed an estimated 5,618 calories during the event based upon what the researchers observed. This was an estimated 862 calories under the pre-estimate of 6,480 calories. This discrepancy in calories may have been due to the athletes' change in fueling preference during the event. The athlete completed the swim at Freeport Beach in Northeast, Pennsylvania, in 11 hours 28 minutes and 5 seconds at 6:42pm for a total of 24.3 miles, placing him as the third-fastest swimmer to cross Lake Erie. Due to diligent planning and communication with the athlete, the researchers felt that the nutrition preparation and estimated metabolic calorie usage for the event was appropriate.

Post-Event Outcomes

Body composition measurements were again analyzed to determine if the dietary changes achieved the athlete's goals of increasing weight and percent body fat. For consistency of testing, the researchers decided to assess body composition twelve days prior and post-event. The athlete had a positive change in body mass (+3.9%) and body fat percentage (+3.6%) from the time from initial consult to final assessment. The results for body composition can be found in Table 2.

Table 2. Pre- and post-event body composition measures.

Points of contact	**Height**	**Weight**	**Body mass index (kg/m^2)**	**%Body Fat**
Initial Consult (30 days prior to event)	71 in (1.80 m)	169.62 lbs (77.1 kg)	23.79	19.6%
Pre-Event (12 days prior to event)	71 in (1.80 m)	170.06 lbs (77.3kg)	23.85	19.7%
Pre-Event (2 days prior to event)	71 in (1.80 m)	177.1 lbs (80.5 kg)	24.84	24.2%
Post-Event (12 days post-event)	71 in (1.80 m)	177.1 lbs (80.5 kg)	24.84	23.2%
Final Consult (14 days post-event)	71 in (1.80 m)	176.8 lbs (80.3 kg)	24.80	23.2%

While body fat percentage and BMI were maintained post-event for this athlete, factors should be considered when consulting athletes on their nutritional status post-ultra endurance event. In particular, ultra-endurance events are more likely to cause loss of fluid and skeletal muscle, increased anemic states, and swelling from hyponatremia.[19] It is suggested that carbohydrate, fat, and electrolyte intake be considered during recovery, in addition to increases in sodium intake, to counteract the changes that may potentially occur.

It is suggested that the caloric changes that were made may have been a result of the relevant contribution of carbohydrates, fat, and protein availability for the final stages of training and stored energy availability for the event. The emphasis on increasing the athlete's total calories may have also increased the consumption of dietary sources of amino acids naturally. Specifically, a positive nitrogen balance was achieved as total calories were increased synergistically with exercise state to minimize protein catabolism. Elite swimmers have more economical/efficient strokes and protein requirements for achieving optimal protein for metabolic needs ranges from 1.4 to 1.9g/kg/day.[20] By increasing the participant's total calories and advising no change to his current intake of 1.6 to 1.7g/day, this ensured that increased carbohydrate consumption spared protein catabolism. Dietary considerations such as this can improve the training status of an athlete and should be optimized through diet planning by providing a normalized ratio of macronutrients.[20]

Limitations

This case study was not without its limitations. For one, due to the rules imposed by LEOWSA, the researchers could not directly interact with the athlete once he was in the water, nor could they directly measure the consumed liquid supplement. In addition, the researchers had no control of how the athlete was training and what he consumed (e.g., the energy drink prior to the start of the race). The inability to accurately measure the hydration levels during the event may have impacted the results for overall nutrient and hydration intake. However, it is acknowledged that inadequate hydration is a possibility that may occur during ultra-endurance events that would possibly affect heart rate and or performance.[13] Moreover, research has established that it is difficult to assess field assessments of hydration intake, sweat rates/losses, and changes in body mass due to dehydration when compared to athletes that perform on land.[21]

Furthermore, the athlete self-reported his diet and nutritional choices. Nutritional education and scripted instructions were used to guide the athlete when reporting foods and making dietary decisions; however, the researchers, not being Registered Dieticians, could not prescribe specific dietary changes to the athlete. Educational nutritional advice was therefore given based on the expertise of the researchers. These limitations may have led to lack of recorded information regarding serving sizes or underreporting caloric values. The researchers acknowledge the inherent issue with self-reported dietary intake as the possibility of underreporting or omission of nutrients and caloric density. Current recommendations for self-reported data of energy intake should continue as it provides valuable information about nutrient consumption and dietary behaviors; however self-reported energy intake should not be the only measure of energy intake. Therefore, the researchers used the athlete's self-reported dietary log to analyze and interpret them appropriately for the energy needed to prepare for the event, supplying energy during the event, and post event recovery.[22]

Conclusions

This case study yields information on the importance of nutritional considerations and planning for ultra-endurance events such as swimming. Utilizing caloric estimation equations, monitoring weight and body fat percentages, and determining the athlete's efficiencies can provide a more individualized approach for an athlete. The sequencing of training becomes important as the training load increases towards the event and ultra-endurance events elevate the task to balance training and nutrition. Therefore, amateur to elite athletes can see the importance of pre-event and event considerations that could be assisted through understanding the caloric demands based on body composition and energy need equations. The researchers suggest the need to discover the determinants of ultra-endurance needed (training intensity, volume, fluid intake or replacement, nutritional support for an activity) for an athlete to achieve optimal and successful performance of their respective event.

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