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## The Effects of Energy Intake on Upper Respiratory Symptoms in Ultra-Endurance Triathletes

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## Abstract

**Background:** It is unclear whether energy intake can impact the incidence of upper respiratory symptoms (URS). The purpose of this study was to examine if there are differences in energy intake between symptomatic (SYM) and asymptomatic (ASYM) groups of URS in Ironman triathletes.

**Methods:** Thirty-three subjects competing in the Lake Placid Ironman Triathlon (mean  $\pm$  SD: age, 37  $\pm$  8 y; height, 178  $\pm$  8 cm; mass, 76.3  $\pm$  10.4 kg; body fat, 10.8  $\pm$  3.8%) were randomized into either control (CON) or intervention (INT). INT consumed four commercial recovery drinks, two immediately post-race and two 3-hours post-race. Calorie and macronutrient intakes were recorded pre-, during, and post-race. Subjects completed the Wisconsin URS Survey to assess URS over the next two weeks. Two analyses were done by comparing results between CON and INT, and when subjects were classified as either ASYM (= 20) or SYM (= 13).

**Results:** There were no differences in energy intake ( $p > 0.05$ ) and URS (INT, 32  $\pm$  38; CON, 16  $\pm$  23;  $p = 0.155$ ). However, on the race day, SYM (9,044  $\pm$  2,598 kcal) consumed less energy than ASYM (10,991  $\pm$  2,497 kcal) ( $p = 0.044$ ). Also, SYM consumed less energy the day before the race ( $p = 0.031$ ) and post-race ( $p = 0.008$ ). ASYM consumed greater carbohydrate the day before the race ( $p = 0.032$ ), fat the day of the race ( $p = 0.006$ ), carbohydrate post-race ( $p = 0.08$ ), and fat post-race ( $p = 0.002$ ).

**Conclusions:** Overall energy intake was similar between CON and INT. However, when subjects were differentiated by URS, SYM consumed fewer calories the day before the race and the day of the race versus ASYM.

**Keywords:** ultra-endurance exercise, immune function, nutrition, respiratory tract infections

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## Introduction

An Ironman triathlon is unique as it requires triathletes to cover 226 km and introduces many physiological challenges. Specifically, research has demonstrated that intense and prolonged exercise negatively impacts the body's overall immune system (Walsh et al., 2011) and places participants at greater risk of experiencing upper respiratory symptoms (URS) after completing an ultra-endurance event (Nieman et al., 1990; Peters & Bateman, 1983; Walsh et al., 2011). This suggests that exercise intensity and duration may impact the subsequent immune response.

High-intensity and prolonged-endurance exercise may contribute to URS in elite athletes (Cox et al., 2008). Faster finishing time in marathon runners has been considered as a risk factor of infection episodes (Ekblom et al., 2006). A previous study demonstrated URS occurred in 33.3% of runners compared to 15.3% of controls following a marathon race (Peters & Bateman, 1983). These studies suggest that endurance athletes may also become more susceptible to URS after ultra-endurance events. In support of this, Mara et al. (2013) found circulating leukocyte numbers and CD4/CD8 T lymphocyte ratio were altered 6 days after Ironman competition. However, little additional research exists in this area.

The production of salivary immunoglobulin A (SIgA) might be one of the main markers for mucosal immunity, and during prolonged exercise or intensive training it has been found to be reduced (Walsh et al., 2011). Other antimicrobial proteins in saliva, such as  $\alpha$ -amylase, lactoferrin, and lysozyme, are also important for the immune system (Walsh et al., 2011). Reduced SIgA has been suggested to increase an athlete's risk of experiencing URS and prolonged and intense exercise can decrease the secretion of SIgA (Walsh et al., 2011). Previous studies have found resting SIgA levels tend to be

low in elite endurance athletes when compared to non-competitive athletes, suggesting higher intensity exercise may increase risk of URS (Walsh et al., 2011). However, other research demonstrated that SIgA was not associated with URS in ultra-endurance runners.

Diet and nutrition can play a large role in immune function (Costa et al., 2005; Walsh et al., 2011). Macronutrient intake is important to maintain the normal function of immune cells (Gunzer et al., 2012). Carbohydrate (CHO) ingestion has been demonstrated to change patterns of circulating cytokines and natural killer cells following endurance exercise (Nehlsen-Cannarella et al., 1997; Nieman et al., 1997). CHO can increase both intestinal IgA as well as submandibular gland tissue IgA in rats. In Ironman triathletes, the consumption of a high-CHO diet reduced the susceptibility to URS during 6 days of intense training (Costa et al., 2005). However, Costa et al. (2009) found that ingesting CHO with protein (PRO) immediately after prolonged exercise reduces neutrophil degranulation while not altering cortisol, epinephrine, nor-epinephrine, leukocyte proliferation, or SIgA. While it is clear that nutrition can impact immune responses, especially during intense exercise training, it is unclear whether CHO and PRO supplementation can impact immune status and the incidence of URS following an Ironman race. Therefore, the purpose of this study was to examine if there are differences in energy intake between symptomatic (SYM) and asymptomatic (ASYM) groups of URS in Ironman triathletes.

## Methods

### Participants

Thirty-three Ironman triathletes (29 men, 4 women) who competed in the 2013 Lake Placid Ironman Triathlon (mean  $\pm$  SD: age,  $37 \pm 8$  y; height,  $178 \pm 8$  cm; body mass (BM),  $76.3 \pm 10.4$  kg; body fat,  $10.8 \pm 3.8\%$ ) participated in the study. During the race, average ambient temperature, relative humidity, and the wet bulb globe temperature were  $17.9 \pm 1.0^\circ\text{C}$ ,  $79.0 \pm 6.9\%$ , and  $19.1 \pm 1.3^\circ\text{C}$ , respectively. Subjects trained on average  $15 \pm 4$  hours per week and had an overall average finish time of  $686 \pm 152$  min. After an explanation of the study's procedures, subjects provided written and informed consent to participate in this study, which was approved by the University of Connecticut Institutional Review Board.

### Study Design

Upon finishing the race, subjects were assigned to either the control (CON,  $n = 18$ ) or intervention (INT,  $n = 15$ ) groups. Groups were randomly assigned by finish ordering, so that every other subject would be assigned to the control group. Baseline (BASE) data collection occurred one day before the race. On the race day, data were collected pre-race (PRE), immediately post-race (1POST), and three hours

post-race (3POST). The last day of on-site data collection occurred one day after the race (AMPOST). For two weeks following the race, subjects reported any incidence of URS and the accompanying severity via an online Wisconsin Upper Respiratory Symptom Survey (WURSS-21).

### Procedures

During BASE, BM (BWB-800A, Tanita, Tokyo, Japan), height via stadiometer, and percent body fat via handheld Lange Skinfold Calipers (Santa Cruz, CA) were recorded for each subject. After 10 min of seated rest with minimal distractions, subjects passively drooled using a saliva collection device (Salimetrics, State College, PA) into a 2.0 mL graduated free-standing screwcap microcentrifuge tube (Fisher Scientific, Pittsburg, PA) until they reached approximately 1 mL of saliva for two minutes. To reduce potential sample contamination, prior to their arrival it was confirmed that subjects did not consume any food intake, fluid other than water, and brush their teeth within 30 minutes of data collection. Furthermore, subjects performed a mouth rinse with water before saliva collection. Of note, while water temperature was not measured directly, water bottles were kept in the shade but subject to ambient environment conditions. All saliva samples were immediately frozen on site and kept in dry ice until analysis.

During PRE data collection, saliva samples were collected and subjects recorded a 24-hour diet record from the previous day. Subjects completed the race without interference from research staff. Saliva samples were obtained at 1POST and 3POST.

The INT consumed two commercial recovery drinks at each time point after saliva was obtained for a total of four drinks throughout the intervention. Each drink consisted of 270 kcal (CHO, 45 g; PRO, 20 g; fat (FAT), 1 g; sodium, 0.32 g; potassium, 0.68 g) in 11 fl oz bottles. The four recovery drinks resulted in an additional intake of 1,080 kcal (CHO, 180 g; PRO, 80 g; FAT, 4 g) and 44 fl oz for each subject in the INT. Subjects in the CON were instructed to eat and drink as they would normally after completing an Ironman triathlon. There was no other nutritional influence on subjects in either group; however, they were asked to record their dietary intake following the race. Finally, during AMPOST, saliva sample and diet record were collected. Energy intake after the race including breakfast that morning was included. Registered dietitians reviewed all diet logs with subjects to ensure each record was accurate.

### Wisconsin Upper Respiratory Symptom Survey

WURSS-21 was used to monitor the subjects' incidence and severity of URS for two weeks after the race via an online survey. Data were collected at 1–8, 10, 12, and 14 days following the race (11 data points in total).

The overall URS score, the overall severity score, and the overall functional impairment/quality-of-life score were calculated. Subjects were determined to have URS, considered symptomatic, if a subject scored 1 or higher on the global severity question for two or more consecutive days (Nieman et al., 2011).

*SIgA Analysis*

SIgA was determined in duplicate using an indirect enzyme immunoassay kit (Salimetrics, State College, PA) as per the manufacturer’s instruction.

*Energy Intake and Expenditure*

Diet records were obtained and analyzed via Esha nutritional analysis software (Salem, OR). Energy expenditure during swim was estimated via validated equations: METS × BM (kg) × time (min), which was adjusted to use during run and bike (Thompson et al., 2005).

*Statistical Analysis*

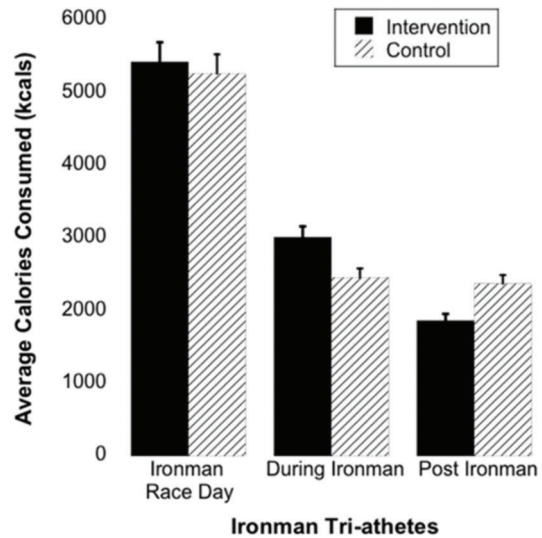
Data are presented as mean ± SD. Due to the interest in determining factors associated with URS, in addition to analyzing data between CON and INT, all data, regardless of original grouping, were also divided into either SYM or ASYM groups and analyzed. Subjects were determined to have URS, considered symptomatic, if a subject scored 1 or higher on the global severity question for two or more consecutive days (Nieman et al., 2011).

Mann–Whitney test was used to examine the differences in overall URS score, overall severity score, and overall function score for CON versus INT. A one-way ANOVA compared energy intake and SIgA concentrations between INT and CON, as well as SYM versus ASYM for their respective time points. An independent t-test compared energy expended for CON versus INT and SYM versus ASYM. Pearson’s bivariate correlations compared overall symptom scores, overall severity scores, overall function impairment scores, energy intake, energy expended, and SIgA concentrations to each other as well as additional variables collected throughout the study, such as finish time and hours trained. These statistical analyses were performed using SPSS (v.21, IBM Corporation, Armonk, NY). Significance was set at  $p < 0.05$ .

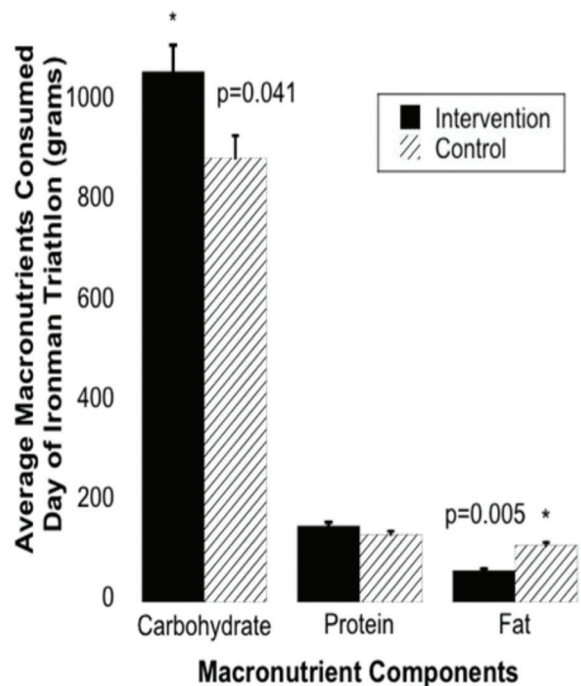
**Results**

*Nutrition*

Figure 1a shows the energy intake the day before the race, the day of the race, during the race, and post-race between CON and INT. Macronutrient intakes on race day (Figure 1b), during the race (Figure 1c), and after the race



**Figure 1a.** Average caloric intake on day of an Ironman triathlon. There no differences in groups ( $p > 0.05$ ).

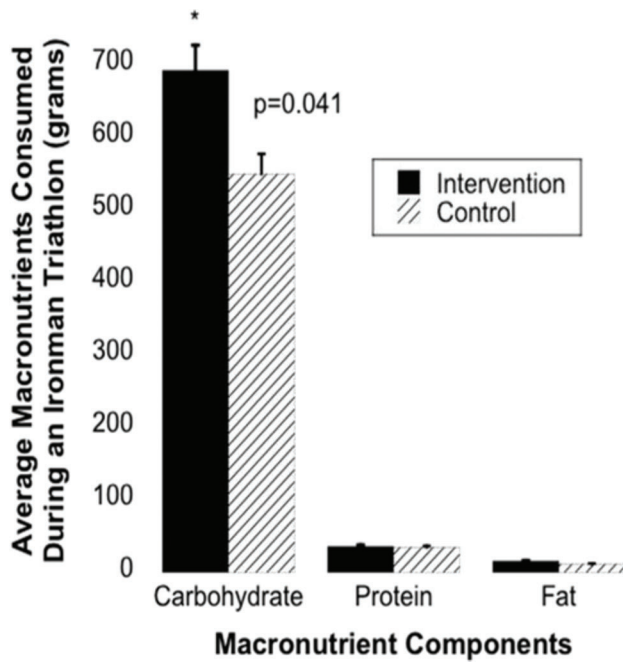


**Figure 1b.** Average macronutrient intake on a race day. \*Significant difference between groups ( $p < 0.05$ ).

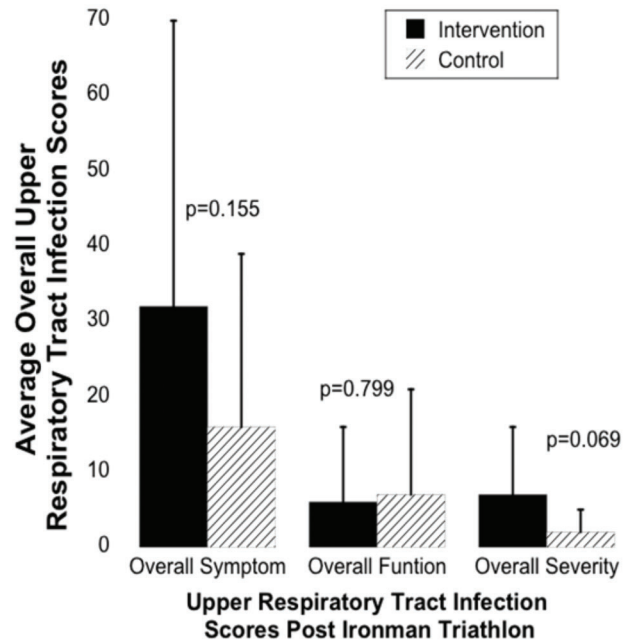
(Figure 1d) are demonstrated. Energy expenditure was similar between INT ( $10,186 \pm 1,756$  kcal) and CON ( $10,804 \pm 1,593$  kcal) ( $p = 0.052$ ).

*Incidence and Severity of URS*

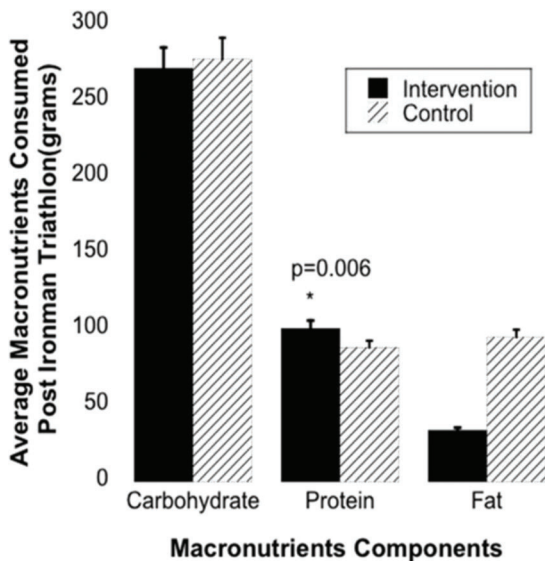
The URS score ( $p = 0.401$ , sum of ranks; INT = 279, CON = 282), the function score ( $p = 0.929$ , sum of ranks; INT = 258, CON = 304), and the severity score ( $p = 0.190$ , sum of ranks; INT = 292, CON = 270) were not different between INT and CON (Figure 2). Fourteen URS were



**Figure 1c.** Average macronutrient intake during an Ironman triathlon. \*Significant difference between groups ( $p < 0.05$ ).



**Figure 2.** Average URS overall symptom, function, and severity scores between groups.



**Figure 1d.** Average macronutrient intake after an Ironman triathlon. \*Significant difference between groups ( $p < 0.05$ ).

reported and were equally distributed between INT ( $n = 7$ ) and CON ( $n = 7$ ). The average length of URS experienced in the INT was significantly greater ( $6 \pm 3$  days) than the CON ( $3 \pm 1$  days) ( $p = 0.022$ ). The URS overall symptom score and the severity score were both positively and significantly correlated with average hours trained ( $r = 0.511$ ,  $p < 0.002$ ).

#### SIgA Concentrations

Saliva flow rates for INT at BASE and AMPOST were  $0.3 \pm 0.2 \text{ mL min}^{-1}$  and  $0.5 \pm 0.4 \text{ mL min}^{-1}$  and for

CON were  $0.4 \pm 0.2 \text{ mL min}^{-1}$  and  $0.5 \pm 0.2 \text{ mL min}^{-1}$ . Secretion rates for INT at BASE and AMPOST were  $16 \pm 10 \mu\text{g min}^{-1}$  and  $20 \pm 16 \mu\text{g min}^{-1}$  and for CON were  $16 \pm 8 \mu\text{g min}^{-1}$  and  $21 \pm 20 \mu\text{g min}^{-1}$ . The average SIgA concentrations for INT at BASE and AMPOST ( $48.8 \pm 14.2 \mu\text{g mL}^{-1}$  and  $44.8 \pm 15.1 \mu\text{g mL}^{-1}$ , respectively) were not different ( $p > 0.05$ ) compared to CON ( $44.4 \pm 15.5 \mu\text{g mL}^{-1}$  and  $36.9 \pm 25.4 \mu\text{g mL}^{-1}$ , respectively). Regardless of intervention group, SIgA concentration at AMPOST was positively correlated with hours trained ( $r = 0.399$ ,  $p = 0.022$ ) and with CHO consumed on race day ( $r = 0.428$ ,  $p = 0.013$ ). SIgA concentration at AMPOST was also positively correlated with CHO consumed following the race ( $r = 0.344$ ,  $p = 0.05$ ), but not with PRO ( $r = 0.129$ ,  $p > 0.05$ ) and FAT ( $r = 0.013$ ,  $p > 0.05$ ) consumed following the race.

#### Factors between Symptomatic and Asymptomatic Population

Any subjects who met the URS criteria were considered symptomatic. Over the 11 time points, subjects were divided into either SYM or ASYM (SYM = 13; ASYM = 20). One subject experienced two separate URS in the two weeks post-race, which brings the total of URS to 14. The SIgA concentration at BASE was greater in SYM ( $p = 0.024$ ) compared to ASYM, but there was no difference in the SIgA concentration at AMPOST (Figure 3a). Overall race performance was similar for both SYM and ASYM, with the only significant difference occurring in bike time ( $p = 0.04$ ) (Figure 3b).

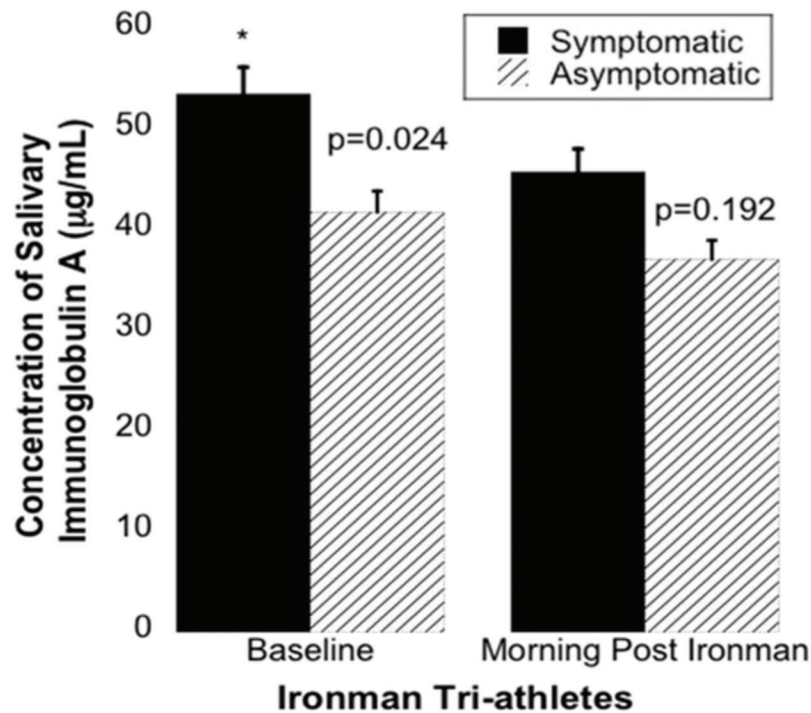


Figure 3a. SIgA concentration between symptomatic and asymptomatic groups. \*Significant difference between groups ( $p < 0.05$ ).

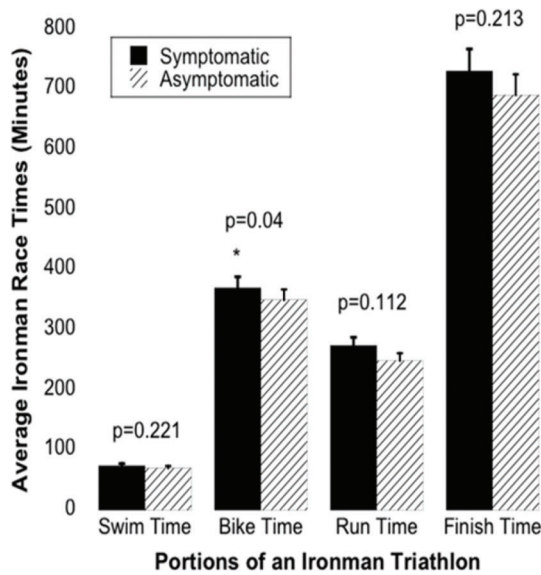


Figure 3b. Average race times of the symptomatic and asymptomatic groups. \*Significant difference between groups ( $p < 0.05$ ).

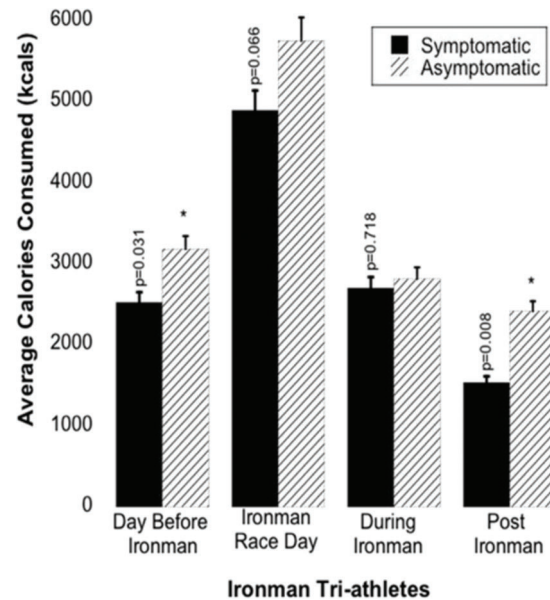


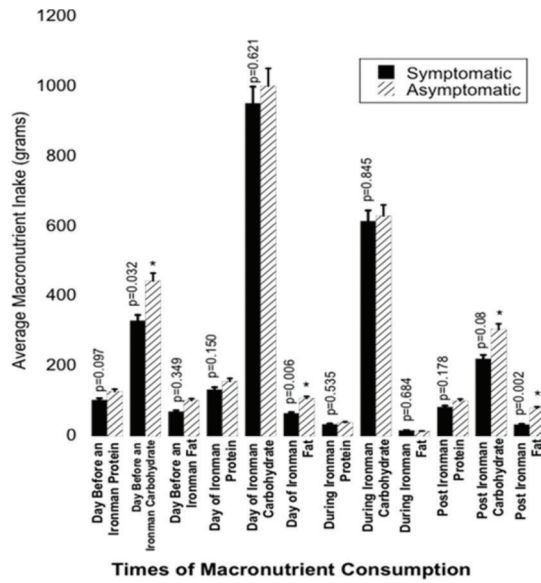
Figure 3c. Average caloric intake of symptomatic and asymptomatic groups the day before, the day of, and post Ironman triathlon. \*Significant difference between groups ( $p < 0.05$ ).

On the race day, SYM ( $9,044 \pm 2,598$  kcal) consumed less energy intake than ASYM ( $10,991 \pm 2,497$  kcal) ( $p = 0.044$ ). CHO intake ( $p = 0.428$ ) and PRO intake ( $p = 0.141$ ) were similar the day of the race for SYM ( $1,782 \pm 499$  g,  $248 \pm 98$  g, respectively) and ASYM ( $1,939 \pm 554$  g,  $297 \pm 83$  g, respectively). FAT intake was higher in ASYM ( $202 \pm 107$  g) than SYM ( $109 \pm 44$  g) ( $p = 0.002$ ). Energy expended during the race did not vary between groups, but there were significant differences in energy intake. Energy and macronutrient intake between

SYM and ASYM are demonstrated in Figures 3c and 3d for different time points.

### Discussion

The purpose of the present study was to determine if there are differences in energy intake between SYM and ASYM groups of URS in Ironman triathletes. The similar



**Figure 3d.** Average macronutrient intake between symptomatic and asymptomatic groups the day before, the day of, and post Ironman triathlon. \*Significant difference between groups ( $p < 0.05$ ).

energy and macronutrient intake that naturally occurred between INT and CON made isolating the effect of our intervention difficult. The post-race nutritional supplementation did not result in a reduction in the incidence or severity of URS, nor differences in SIgA concentrations for INT. However, analyses between the SYM and ASYM subjects revealed potential nutrient-based results for URS. Among all 33 subjects, 14 URS were reported within two weeks of competing in the Ironman race.

While total kilocalorie intake was similar, the INT and CON consumed similar amounts of CHO and PRO on the race day, whereas the amount of FAT consumed by the CON on the race day was larger than the INT. Despite the nutritional supplementation there were no differences in incidence and severity of URS between the INT and CON.

Interestingly, URS risk was potentially influenced by differences in nutrition the day of and immediately following the race as evidenced by the SYM and ASYM analyses. Kilocalorie intake was significantly less in the SYM subjects compared to ASYM the day before the race and post-race time point, suggesting an important impact of energy intake surrounding the race. Also, SYM consumed less energy intake than ASYM on the race day. While similar amounts of CHO and PRO were consumed by SYM and ASYM, ASYM had a greater amount than SYM on the race day. Additionally, higher SIgA concentrations at AMPOST were correlated with greater amount of CHO consumed on race day and with increased hours trained. The higher URS overall symptom score and the severity score were also associated with increased hours trained. Previous research has shown CHO intake to reduce the susceptibility to URS during intense training in Ironman triathletes (Costa et al., 2005). However, the effect of CHO

ingestion on URS is still inconclusive and some research indicates no significant effect on it (Colbey et al., 2018; Nieman et al., 2008).

Like the previous studies mentioned (Costa et al., 2012; Nieman et al., 2002; Walsh et al., 2011), the present study found decreases in SIgA concentration after prolonged exercise, which suggests an increased risk of URS (Walsh et al., 2011). In the current study, AMPOST SIgA concentration was positively correlated with CHO consumed on race day, indicating that AMPOST SIgA concentration may be positively influenced by CHO consumption. Similarly, Allgrove (2007) indicated that CHO ingestion increased SIgA compared to fasting during prolonged exercise. Additionally, Costa et al. (2005) found CHO ingestion increased SIgA response and decreased risk of URS during 6 days of intense training in Ironman triathletes.

Divergent from the current study results, when Nieman et al. (2002) examined the change in SIgA concentration following a marathon after ingesting 650 mL of a CHO solution or 650 mL of a placebo solution, the average SIgA concentrations decreased but the change in concentration was not affected by CHO ingestion. Furthermore, Costa et al. (2012) performed a similar study looking at the influence of a CHO-PRO solution on SIgA concentration following exercise. This study found SIgA concentrations decreased after exercise, but the CHO-PRO solution did not have any effect on SIgA concentration (Costa et al., 2012). Based on these studies, the relationship between CHO consumption and SIgA concentrations remains unclear and inconsistent.

In this study, the BASE SIgA concentration was significantly greater in the SYM. Though there were no significant differences in AMPOST and changes in SIgA concentration. The elevated SIgA concentrations in the SYM at BASE contradicts previous literature and the inverse relationship between SIgA and the incidence of URS. This finding suggests that there may be many variables (such as age, gender, ethnicity, fitness level, or genetics) that can influence SIgA concentrations that the current study did not control.

AMPOST SIgA concentrations were significantly and positively correlated with hours trained. This indicates that the more hours a subject trained the higher their SIgA concentrations were at AMPOST. This finding contradicts previous literature that has found resting SIgA concentrations to decrease throughout a training season. Gleeson et al. (1995) found that post-exercise SIgA concentrations in elite swimmers decreased over a 7-month training period. Similar to Gleeson et al., Allgrove (2007) found SIgA concentrations to decrease after exercise in elite swimmers over a 6-month period of training and competition. One theory behind the current findings may be that those who train more are more experienced and therefore their body has developed an adaptation to their training.



Furthermore, SIgA concentrations were tracked for a longer period of time in previous studies as opposed to the current study. There is currently no literature to support this theory and therefore the relationship between SIgA concentrations and hours trained remains undefined.

Previous literature has suggested that increased volume of training leading up to competition may increase URS report post-competition (Allgrove, 2007; Tiollier et al., 2005). The current study found no differences in the hours trained when comparing the SYM and ASYM groups. However, among all 33 subjects, there was positive correlation between hours trained and overall symptom scores ( $r = 0.51$ ). The current findings are consistent with the previous findings, looking at the incidence and severity of URS during 3 weeks of military training followed by a 5-day combat course (Tiollier et al., 2005). This study found an increased incidence of URS over the duration of study with the most URS occurring 11 days into training and suggested the large volume of training could have resulted in the increased incidences of URS. The frequency of URS has been reported to increase during a period of intense training in endurance athletes (Walsh et al., 2011), which also supported the current findings.

This study is not without limitations. This field study did not restrict the diets of subjects outside data collection time points. Many Ironman triathletes were well aware of the importance of replenishing their energy stores during the race and post-race; thus, both groups ate similar diets despite the nutritional supplementation. Also, for two weeks following the race, physical activity or nutrition were not controlled. Importantly, while the nutritional intervention may not have altered immune status, interesting observations were noted in immune parameters and nutritional intake among symptomatic and asymptomatic subjects, regardless of the intervention group. Also, due to the various locations of our subjects, all URS were self-reported via an online survey. Many previous studies in the literature have required physician verification but this was not possible in the present study. The present study only had four female participants, all of whom reported experiencing an upper respiratory tract infection post-race. Due to the small number of female subjects, and not having any ASYM females to compare with, it cannot be concluded that gender influences the incidence of upper respiratory tract infections. Additionally, URS was measured and no infection status was determined. It was demonstrated that physician-diagnosed upper respiratory tract infection is a gold standard to quantify an episode of infection (Cox et al., 2008). Finally, other potential impacting factors, such as pollen and pollutants, were not determined in this study.

### Practical Applications

The post-race nutritional supplementation did not result in differences between INT and CON in energy intake. The

SYM group consumed significantly fewer kilocalories the day before the race and post-race and the ASYM group consumed a greater amount of CHO the day before the race, FAT the day of the race, CHO post-race, and FAT post-race. Thus, CHO and FAT ingestion might be associated with decreased the risk of URS. Additionally, the higher SIgA concentration, which indicated a lower risk of URS, at AMPOST was correlated with a greater amount of CHO consumed on the race day. Despite great variability within subjects, overall severity and overall symptom scores were positively associated with total hours trained per week suggesting that greater training volume may increase the incidence and severity of URS.

### Acknowledgments

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