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# Post-Race Nutritional Supplementation Effects on the Incidence and Severity of Upper Respiratory Tract Infection in Ironman Tri-athletes

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# Post-Race Nutritional Supplementation Effects on the Incidence and Severity of Upper Respiratory Tract Infection in Ironman Tri-athletes

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## APPROVAL PAGE

Masters of Science Thesis

### Post-Race Nutritional Supplementation Effects on the Incidence and Severity of Upper Respiratory Tract Infections in Ironman Tri-athletes

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## Post-Race Nutritional Supplementation Effects on the Incidence and Severity of Upper Respiratory Tract Infection Symptoms in Ironman Tri-athletes

Scientific evidence suggests there is an increased risk of experiencing symptoms associated with upper respiratory tract infections (URTI) after completing an ultra-endurance event. Nutritional intake to reduce the incidence and severity of URTIs has been examined, but the use of recovery beverages post race remains inconclusive in regards to reducing the incidence and severity of URTIs. **Purpose:** Examine the effect of a post race nutritional supplementation on the incidence and severity of URTI symptoms in Ironman tri-athletes. **Methods:** Thirty-three subjects (29 men, 4 women) competing in the 2013 Lake Placid Ironman triathlon participated in this study (mean  $\pm$  SD; age:  $37 \pm 8$  yrs; height:  $178 \pm 9$  cm; weight:  $76.3 \pm 10.6$  kg; body fat:  $10.8 \pm 3.8\%$ ; finish time:  $686 \pm 152$  min). Data was collected at five time points: Baseline (BASE), pre race (PRE), 1 hour post race (1POST), 3 hours post (3POST) race, and the morning after the race (AMPOST). At each time point subjects were asked to give a urine sample as well as a saliva sample. Urine samples were used to assess hydration status via urine color, and urine specific gravity. Body mass was also collected at each time point to observe changes in hydration status throughout the study. Saliva samples were used to assess salivary immunoglobulin A (SIgA) concentrations at each time point. Subjects were randomized into either the control (CON) group or intervention (INT) group and followed self-regulated pre and post race dietary practices. The INT group consumed a total 4 commercial recovery shakes: two immediately post race and two 3 hours post race (270kcal, 45g carbohydrate, 20g protein, 1g fat, 11 fl oz per shake). Subjects completed the Wisconsin Upper Respiratory Symptom Survey (WURSS-21) to

assess the incidence, and physiological and functional symptoms of reported URTIs at 11 time points over the next two weeks. Post-hoc analysis was done to compare energy expended and energy intake throughout the study. **Results:** Overall severity scores had a possible range of 0 to 77 the mean overall severity scores for the INT and CON groups (over 11-time points) were  $7 \pm 9$  and  $3 \pm 3$  respectively ( $p=0.069$ ). Overall symptom and function scores had ranges of 0-770 and 0-693 respectively. The average symptom score for the INT group was  $32 \pm 38$  and  $16 \pm 23$  for the CON group. Overall symptom and severity scores were positively correlated with hours trained (Symptom:  $r = 0.511$ ,  $p = 0.002$ ; Severity:  $r = 0.452$ ,  $p = 0.008$ ). Fourteen URTIs were recorded in the two weeks post race with an average length of  $5 \pm 3$  days and an average severity of  $2 \pm 1$ . SIgA concentrations at BASE and AMPOST were not significantly different between groups ( $p = 0.401$  and  $p = 0.279$ , respectively). However the AMPOST SIgA concentrations were positively correlated with hours trained ( $r = 0.399$   $p = 0.022$ ), carbohydrate consumption on race day ( $r = 0.428$   $p = 0.13$ ) as well as carbohydrate consumption post race ( $r = 0.344$   $p = 0.05$ ). INT had significantly greater carbohydrate intake on race day ( $p = 0.041$ ), and during the race ( $p = 0.041$ ) as well as a significantly greater consumption of protein post race ( $p = 0.006$ ). **Conclusions:** Within the confines of this study, the nutritional supplementation did not alter the severity of URTI symptoms within the 2 weeks following an Ironman race. Despite great variability within subjects overall severity and overall symptoms scores were positively associated with total hours trained per week suggesting that over training may increase the incidence and severity of URTI symptoms.



## Review of the Literature

Amongst all athletic events in existence today, there is none quite like an Ironman Triathlon. In order to complete a full Ironman, tri-athletes are required to swim 2.4 miles in open water, immediately followed by biking 112 miles and finally running a full marathon 26.2 miles. Ironman tri-athletes cover 140.6 miles in a span of 8 hours for elite competitors or up to 17 hours for those just trying to finish.

As imagined an Ironman triathlon takes a physiological toll on the bodies of its finishers. Anecdotal evidence and scientific observation suggest that athletes are at greater risk of experiencing upper respiratory tract infection (URTI) symptoms after completing an ultra-endurance event.<sup>1,2,3</sup> It is widely accepted that the relationship between exercise intensity and immune response is considered to be “J-shaped.”<sup>4</sup> Where moderate intensity exercise reduces the risk of URTI symptoms and high intensity or prolonged exercise increases the risks of experiencing an URTI symptoms.<sup>4</sup> This evidence not only supports, but also explains how ultra-endurance athletes become more susceptible to infections after competing in ultra-endurance events.

The literature suggests that the number and function of immune cells is altered by acute and chronic exercise. Lymphocytosis, a large increase in the number or proportion of lymphocytes in the blood, is experienced during and immediately after exercise. The extent is proportional to the intensity and duration of the exercise.<sup>3</sup> This number of immune cells then falls below pre-exercising levels during the early stages of recovery but return to resting levels within 24 hours.<sup>3,4</sup> Along with observing immune cells, researchers have recently began to use the production of salivary immunoglobulin

A (SIgA) as a marker of mucosal immunity as it is the body's first line of defense against pathogens. Data has shown that prolonged exercise and intensive training reduces SIgA secretions.<sup>3</sup> The incidences of lymphocytosis and reduced SIgA are believed to play a great role in increasing an athlete's risk of experiencing URTI symptoms.

Evidence supports the idea that ultra-endurance athletes, such as Ironman tri-athletes are prone to immunosuppression after competing. High incidences of URTI symptoms, during recovery can have detrimental effects on a tri-athlete's training. As a result many supplements such as antioxidants, bovine colostrum, and glutamine have been studied to reduce the incidences of URTIs. The present review will primarily focus on those involving protein (PRO) and carbohydrates (CHO) and their influence on the incidence and severity of URTI symptoms post ultra endurance events.

### **Ironman Triathlons**

As previously mentioned an Ironman triathlon is unlike any other race. It requires it's competitors to cover 140.6 miles (2.4 mile swim, 112 mile bike and 26.2 mile run). During this event tri-athletes experience many physiological challenges that must be overcome to successfully complete the race. With finish times ranging from 8-17 hours an Ironman tri-athlete primarily utilizes their aerobic energy system while competing. It is well understood that CHO and fat play a large role in high intensity aerobic metabolism. It is suggested that total CHO oxidation during prolonged exercise (up to 6 hours) exceeds the estimated CHO stores in liver and muscle.<sup>5</sup> This implies that other sources of fuel are required for oxidation in ultra endurance events. Current literature suggests that maximal fat utilization was elicited at an intensity of 63%  $VO_{2max}$ .<sup>6</sup> With that in mind, one study estimated that the intensity of the run portion of an Ironman

triathlon is approximately 66%  $VO_{2max}$ .<sup>7</sup> This predicates that fat may make a considerable contribution to overall fuel use during an Ironman triathlon. In addition, Jeukendrup et al. postulated that long-distance tri-athletes may have an increased capacity to oxidize fat.<sup>8</sup>

Along with depleted energy stores, tri-athletes also tend to lose copious amounts of fluid and sodium as they sweat throughout the competition. While also trying to compensate for fluid losses, tri-athletes must also maintain proper level of hydration to help with thermoregulation. Faster finishers typically have a higher risk of experiencing heat related illnesses due to high relative intensity, and finishing around the hottest part of the day. Late finishers are still at risk, but this risk is minimized as they may race at a lower relative intensity, and finish in cooler parts of the day. The body requires a lot of energy to overcome these challenges. In many cases the energy needed to for example thermoregulate, is borrowed from other systems such as the immune system.<sup>3</sup> In order to conserve energy the body undergoes several physiological changes that may actually increase an athlete's risk of experiencing an URTI.<sup>4</sup>

### **Physiological Disturbances Associated with Prolonged Exercise**

The body's first line of defense is the innate immune system. It is responsible for attacking unknown pathogens in the body. The acquired immune system comes into play when the innate system fails, or is suppressed. The acquired immune system relies on the body's memory of previous infections, to properly respond to a specific pathogen. Research has shown that prolonged, intense exercise has a greater impact on the innate immune system when compared to the acquired immune system.<sup>3</sup>

It is also believed that following prolonged exercise, such as an ultra-endurance event, leukocyte number, cortisol, cytokine, and catecholamine concentrations increase, while lymphocyte numbers decrease. This was established when Nieman et al observed 62 experienced marathon runners running for 2.5-3 hours at  $76.4 \pm 0.6\%$  of their  $VO_{2Max}$ .<sup>9, 10, 11</sup> The immune responses of the 62 runners were compared to those of 10 non-athletic resting subjects. Nieman et al found that leukocyte numbers peaked at ~3 hours post-exercise, where the decrease in lymphocyte numbers lasted at least 6 hours post-exercise (Figures 1 and 2).<sup>12</sup>

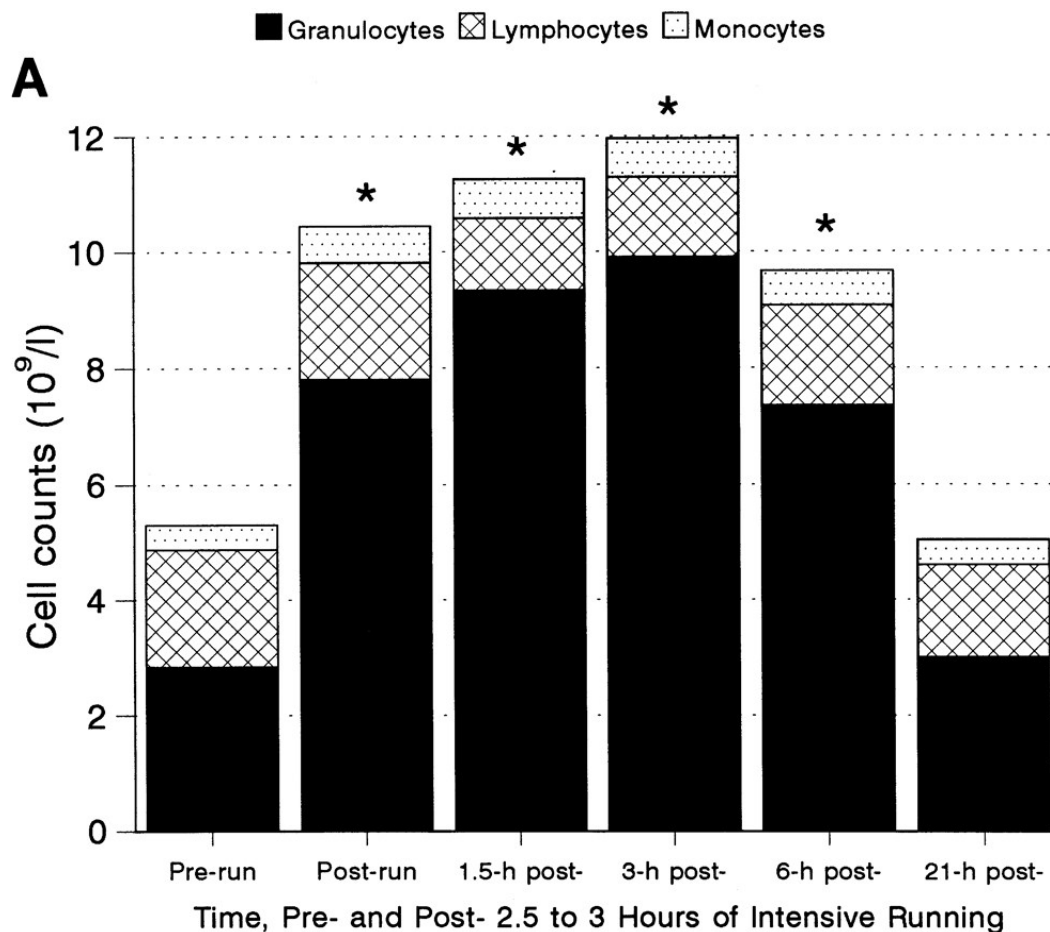


Figure 1: Leukocyte numbers post intensive exercise. Nieman 1997.<sup>12</sup>

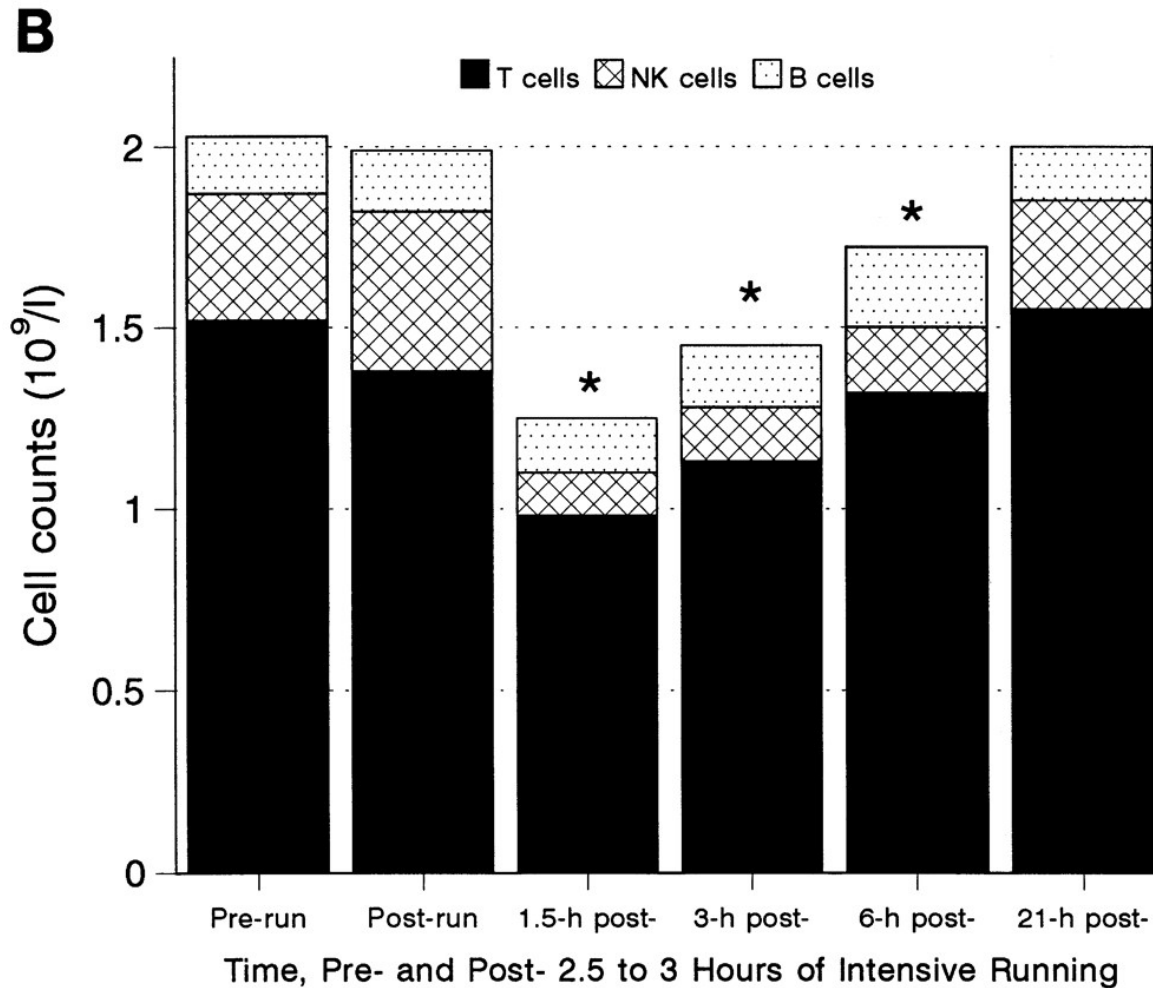


Figure 2: Decrease in lymphocyte numbers post intensive exercise.  
Nieman 1997.<sup>12</sup>

Neutrophils and natural killer cells (NK), the innate immune system's best phagocytes, play an important role in the body's early response to infections. Neutrophils are responsible for the degradation and repair of damaged tissues. NK cells have the ability to react against and destroy another cell without prior sensitization to it.<sup>13</sup> It is during times of intense training that athletes have shown to have lower resting and post-exercise neutrophil phagocytic, and NK cell activity levels when compared to

non-athletes.<sup>13</sup> Evidence has indicated that exhaustive exercise can dramatically weaken neutrophil phagocytic activity.<sup>14</sup> LiLi et al found that after a single bout of 60 minutes of cycling at 60% VO<sub>2Max</sub> there was a significant decrease in neutrophil degranulation and oxidative burst activity on a per cell basis.<sup>15</sup> Studies with similar findings can be found in Table 1.

**Table 1: Neutrophil and natural killer cell levels post ultra-endurance events.**

<b>Authors</b>	<b>Major Finding</b>
<b>Smith et al. 1990<sup>16</sup></b>	<b>Reduced neutrophil activation at rest and 6 hours after 60 min cycling in cyclist compared with non-athletes</b>
<b>Hack et al. 1994<sup>17</sup></b>	<b>Neutrophil activity was lower at rest and 24 hours post standard exercise session in distance runners during intense training compared to moderate training, and when compared with non-athletes</b>
<b>Baj et al. 1994<sup>18</sup></b>	<b>Neutrophil function in athletes is similar to non-athlete controls during periods of low-volume training and significantly suppressed during periods of intense training</b>
<b>Pyne et al. 1995<sup>19</sup></b>	<b>Neutrophil activation in elite swimmers declined as training intensity increased for 12 weeks, despite maintenance of neutrophil number</b>
<b>LiLi et al. 2007<sup>15</sup></b>	<b>After a single bout of prolonged exercise there was a significant decrease in neutrophil degranulation and oxidative burst activity on a per cell basis. This lasted for longer than 3 hours post exercise.</b>

As previously mentioned researchers also use SIgA to measure mucosal immunity. Research suggests that there is an inverse relationship between SIgA concentrations and the incidence of URTI symptoms.<sup>3</sup> Several studies have found resting SIgA levels tend to be low in elite endurance athletes when compared to non-competitive athletes. Gleeson et al found that resting and post exercise SIgA concentrations in elite swimmers were significantly lower than those of moderately

active controls.<sup>20</sup> Likewise Tomasi et al observed significantly lower SIgA concentrations in elite cross-country skiers when compared to moderately active controls.<sup>21</sup> It is also believed that SIgA concentrations may be influenced by training intensity and load. Tharp et al found that SIgA secretion reduced during times of intense training over a 4-month season with collegiate swimmers.<sup>22</sup> In a similar study, Allgrove monitored the SIgA concentration levels in both male and female elite swimmers over a 6-month period of training and competition. Allgrove did not find a significant change throughout the study period but did find a significant difference between genders. (Figure 3).<sup>23</sup> Similar studies can be found in Table 2.

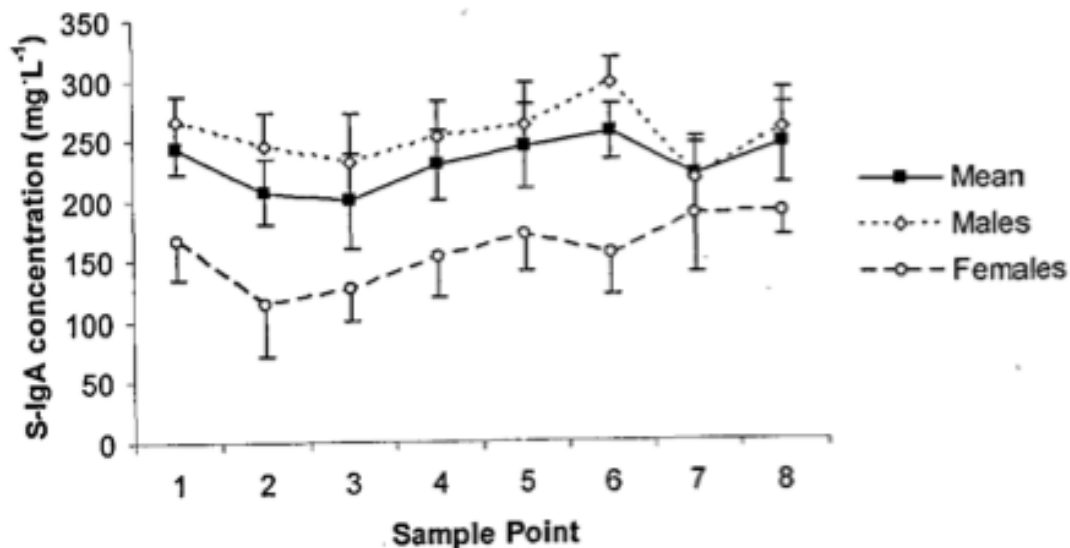


Figure 3: Salivary immunoglobulin A concentrations over a 6 month period of training and competition. 1: Baseline; 2:5 wks following 4 wks of intense training; 3:7wks in following 1 wk of taper; 4:9 wks in between competitions; 5:11 wks prior to intense training; 6:17 wks following 5wks of intense training; 7:22 wks prior to competition; 8:26wks one week after the last competition. Allgrove, 2007<sup>23</sup>

**Table 2: Salivary immunoglobulin A concentrations and exercise**

<b>Authors</b>	<b>Major Finding</b>
Tomasi et al. 1982 <sup>21</sup>	SIgA levels were found to be low in cross country skiers when compared to non-athlete controls
Tharp et al. 1990 <sup>22</sup>	Resting and post-exercise SIgA decreased with intensity over a 4-month season in collegiate swimmers
Mackinnon et al 1993 <sup>24</sup>	Declines in SIgA in field hockey and squash players after an intense bout of exercise was predictive of the development of URTI
Gleeson et al. 1995 <sup>20</sup>	Resting and post-exercise SIgA decreased with intensity over a 7-month season in elite swimmers
Gleeson et al. 1999 <sup>25</sup>	Declines in SIgA in elite swimmers through out a season was predictive of the development of URTI
Carins et al. 2002 <sup>26</sup>	SIgA concentration decreases over a 19-day Royal Australian Air Force survival course
Tiollier et al. 2005 <sup>27</sup>	Found no correlation between low SIgA and incidence of URTI
McKune et al. 2005 <sup>28</sup>	In experienced ultra-endurance athletes SIgA increased by 10% immediately after the race, then was followed by a 6% decrease at 3 hours, a 10% decrease at 24 hours, and a 6% decrease at 72 hours
Allgrove et al. 2007 <sup>23</sup>	Eating during prolonged exercise increased SIgA when compared to fasting during exercise
Naville et al. 2008 <sup>29</sup>	Found that the decrease in SIgA concentration was correlated to experiencing URTI symptoms

### **Ultra-Endurance Events Effects on Immune Function**

It is widely accepted that the relationship between exercise intensity and immune response is considered to be “J-shaped” (Figure 4).<sup>4</sup> As indicated by the shape of the curve, moderate exercise, is very beneficial and reduces the risk of experiencing URTI symptoms. Though it is not surprising that a sedentary lifestyle may have a negative impact on an individual’s health, many are surprised to see that intense or prolonged exercise has an even greater influence on the incidence URTI symptoms.



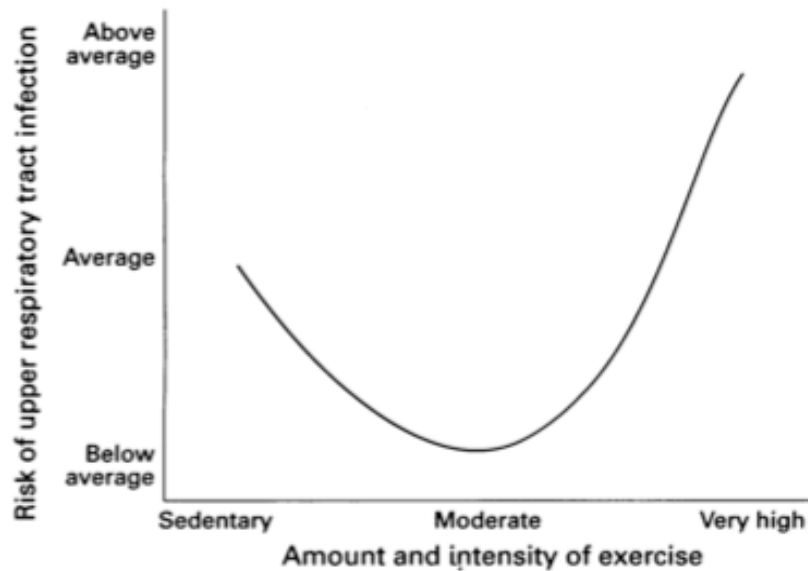


Figure 4: The “J-Shape” Curve relating intensity of exercise with risk of upper respiratory tract infections Nieman 1995<sup>4</sup>

The first study to make this observation was performed by Peters and Bateman. They observed 150 randomly selected runners in the 1982 Two Oceans Marathon (Cape Town, South Africa) and 150 live-in controls who did not take part in the marathon. URTI symptoms occurred in 33.3% of runners compared to 15.3% of controls (Figure 5).<sup>1</sup>

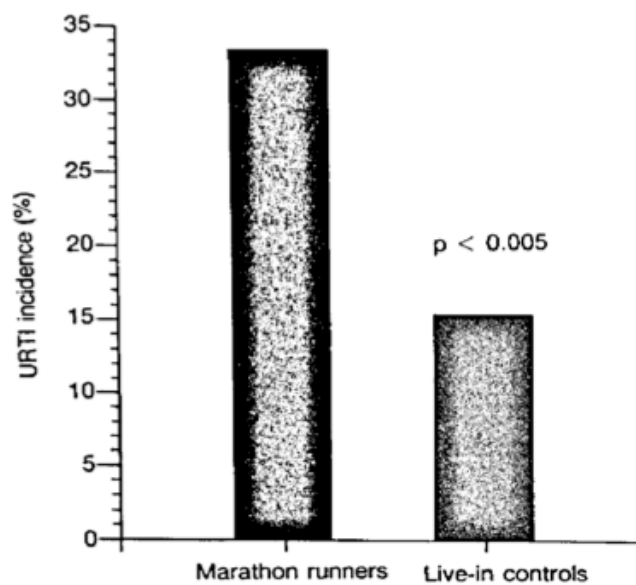


Figure 5: Incidence of URTI in marathon runners vs. controls. Peters and Bateman 1983<sup>1</sup>

Shortly after Peters and Bateman published their results, Nieman analyzed questionnaires from 2,311 runners in 1987 Los Angeles marathon. It was found that 12.9% of runners reported URTI symptoms after the race compared to 2.2% of experienced runners who did not participate in the race (Figure 6).<sup>2</sup> Both studies also found a correlation between the incidences of URTI symptoms and faster finish times, which supports the “J-shape” curve theory. Since Nieman’s publication in 1990, several other studies have had similar findings as described in Table 3.

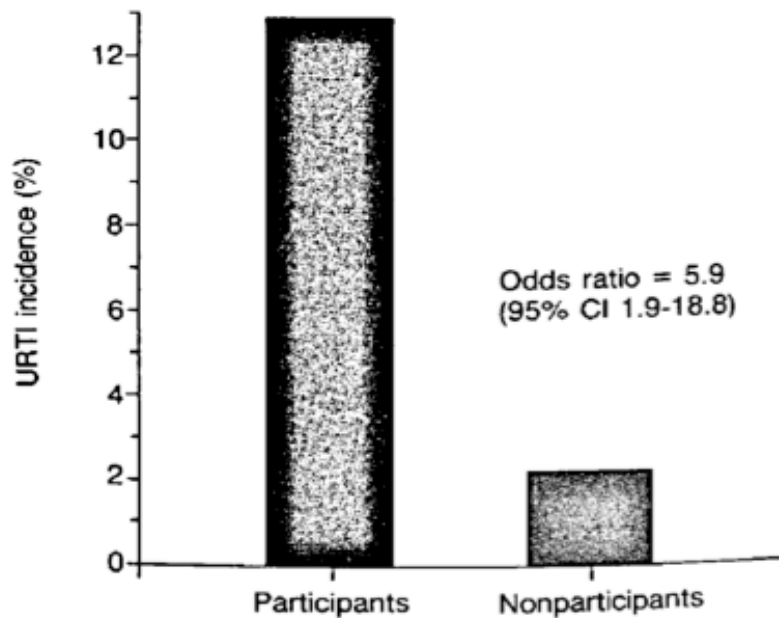


Figure 6: Incidence of URTI in race participants vs. non-participants. Nieman1990.<sup>2</sup>

**Table 3: Incidences of Upper Respiratory Tract Infection Symptoms in Ultra-Endurance Athletes**

Authors	Subjects	Research Design	Method of Determining URTI	Major Finding
Nieman et al. 1989 <sup>30</sup>	294 runners	Retrospective study 2 months before and 1 week post 5km and 10km races	2 month training recall of URTI symptoms, 1 week after race self reported symptoms	Race distance did not cause incidence of URTI
Nieman et al. 1990 <sup>2</sup>	2,311 Los Angeles marathon runners	Retrospective study: 2 months pre marathon, and 1 week post marathon reported URTI symptoms	2 month training recall of URTI symptoms, 1 week after marathon self reported symptoms	Training >97km per week vs. < 32km per week is at greater risk of experiencing URTI
Heath et al. 1991 <sup>31</sup>	530 male and female runners	Monthly log for 12 months. Recorded daily running habits, other exercise activity, and health problems	Monthly log	Risk of URTI increases with mile dosage
Peters & Bateman 1993 <sup>1</sup>	141 marathon runners vs. 124 live in controls	Retrospective study 2 week recall of URTI symptoms post race	2 week self reported URTI symptoms questionnaire and daily log	URT I occurrence twice as high in runners than in controls
Peters et al. 1993 <sup>32</sup>	84 runner vs. 73 non runners	Randomized, double blind vitamin C supplementation 600 mg/day for 21 days pre race	2 week post race self reported URTI symptoms	Vitamin C supplementation pre race may reduce the incidence of URTI
Nieman et al 1995 <sup>33</sup>	22 male marathon runners vs. 18 controls	Cross sectional 2 month study of URTI rates	2 month health logs to record URTI symptoms	Runners and controls had similar innate immunity, except runners had elevated NK cell activity
Nieman et al 2000 <sup>34</sup>	20 female elite rowers vs. 19 controls	Cross sectional 2 month study of URTI rates	2 month health logs to record URTI symptoms	Rowers and control has similar innate immunity, except rowers had elevated NK cell activity
Nieman et al. 2002 <sup>35</sup>	98 (12 women, 86 males) marathon runners	Two groups carbohydrate vs. placebo	Daily health/sickness log 15 days post race	SIgA decreased in runners and was not influenced by carbohydrate ingestion
McKune et al. 2005 <sup>36</sup>	6 male and 5 female ultra marathon runners	Took blood samples baseline 24 hr of predicted finish time, 10 minutes post race, 3, 24, and 72 hours post race	Pre race, and daily post race URTI symptoms questionnaire	In experienced runners alterations in immunoglobulin concentrations after a race suggest an enhanced immune response.
Peter et al. 2010 <sup>37</sup>	14 male amateur ultra marathon runners	Recorded training log and URTI symptoms for 28 days prior to race.	Self-reported URTI symptoms	URT I symptoms not associated with IgA concentration.
Ansley et al. 2012 <sup>38</sup>	208 London Marathon Runners	Runners randomly recruited.	Daily symptom questionnaire for 15 days post race	URT I symptoms may be allergic rather than infectious in nature

At first it was believed that endurance athletes may have vulnerable immune systems compared to non-endurance athletes. When Nieman compared female elite rowers vs. non-athletes<sup>34</sup> and marathon runners vs. sedentary individuals<sup>33</sup> their innate immune systems were similar during months of training. The only exception was that NK cell activity at rest was elevated in athletes (Figure 7).<sup>39</sup>

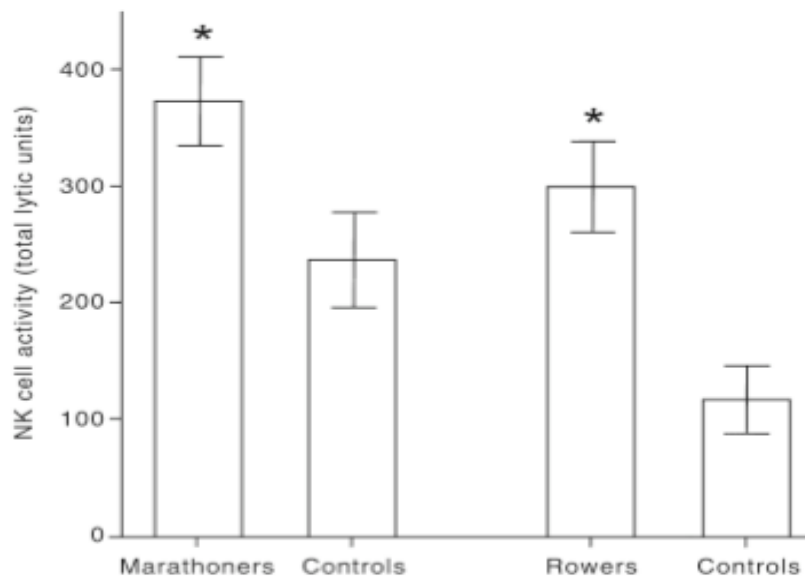


Figure 7: Natural killer cell activity in athletes vs. controls Nieman 2000<sup>39</sup>

Although the actual cause and effect for experiencing URTI symptoms is debatable there is a general consensus that athletes are more susceptible to infection 3-72 hours post ultra endurance events (Figure 8).<sup>40</sup> This “open window” or state of altered immunity is a result of physiological changes to the immune system that occur during and after exercise.

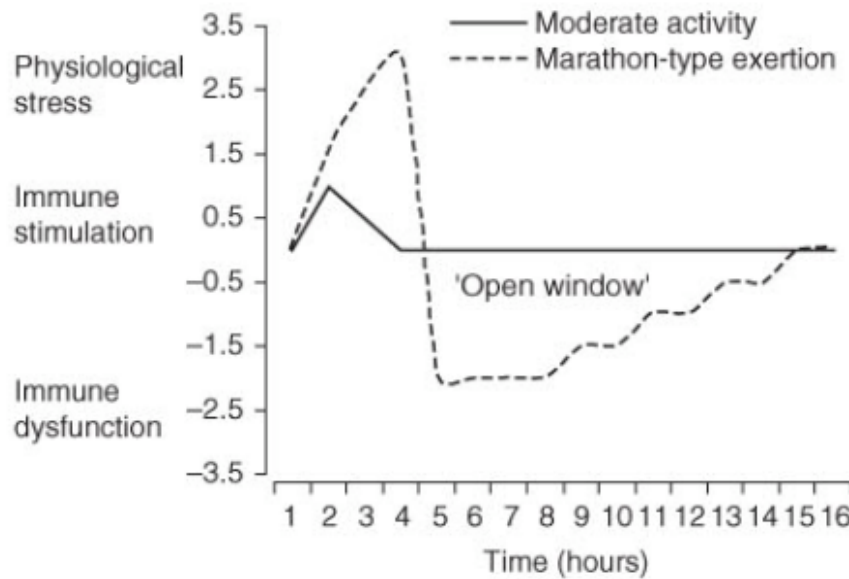


Figure 8: The “Open Window” theory Nieman 2007<sup>40</sup>

### **Nutritional Influences on URTI Symptoms Post Ultra Endurance Events**

Knez et al surveyed 37 ultra endurance athletes and reported that over 97.5% and 78.3% of the subjects supplemented with vitamin C and E respectively.<sup>41</sup> The most common reasons for using these supplements were to prevent or reduce cold symptoms, and to boost their immune system. In efforts to improve recovery from demanding events, a myriad of research studies have examined the influence of nutrition on an athlete’s risk of experiencing URTI symptoms. To date most literature has focused on nutritional interventions that occur pre or during exercise. There is little research looking at the influences of post exercise CHO and PRO consumption on the incidence and severity of upper respiratory tract infections in ultra endurance athletes. However it is believed that CHO supplementation helps maintain plasma glucose concentrations, which attenuates the rise in plasma concentrations of stress hormones

and alleviates several but not all, immune suppressive changes that are associated with intense prolonged exercise.<sup>42</sup> PRO is needed post exercise to ensure there are sufficient amino acids to produce important immune variables such as cytokines, and immunoglobulins.<sup>43</sup> The amount of CHO and PRO deficiency is believed to influence the level of immune system impairment.<sup>44</sup> As a result the current review will mainly be focused on CHO and PRO ingestion.

### *Physiological Influences From Carbohydrate and Protein Consumption*

CHO loading is a dietary practice commonly used by endurance athletes prior to competing in ultra endurance events. Though fat is also a huge fuel source during an Ironman race, tri-athletes supplement mostly with CHO because it is fast and often readily available. In relation to the immune system and risk of experiencing URTI symptoms, glucose, which is manufactured from CHO in the body, is the main source of fuel for immune cells. Blood glucose levels are indirectly proportional to the levels of cortisol, epinephrine, and norepinephrine in the body.<sup>45</sup> Therefore when blood glucose levels are low, due to lack of fuel being metabolized to sugar, there is large amount of cortisol, epinephrine, and norepinephrine in the body.<sup>45</sup> The increase of these specific stress hormones, cause immune cells such as neutrophils and NK cells, to not function properly.<sup>46</sup>

PRO availability is also essential to immune function as it aids in the production of immune variables such as cytokines, and immunoglobulin. The severity of PRO deficiency is strongly correlated with the magnitude of immune function impairment.<sup>46</sup>

### *Carbohydrate and Protein Consumption Effect on Immune Indices*

Ample research has been done looking at CHO and PRO consumption and its effects on immune indices. One study by Costa et al found that a high CHO diet throughout 6-day exercise protocol significantly increased SIgA concentrations in ultra endurance tri-athletes.<sup>47</sup> (Figure 9)

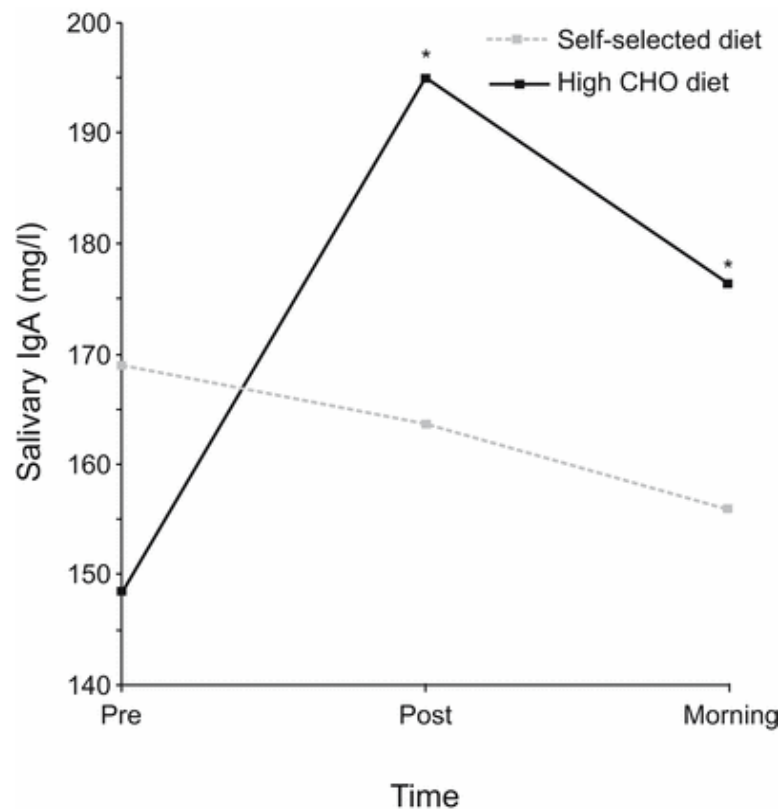


Figure 9: The average salivary immunoglobulin A concentrations over 6 days pre, post and 24 hours after exercise comparing high carbohydrate diet to self selected diet. Costa 2005<sup>47</sup>

When researchers observed the effect of pre exercise CHO consumption in combination with CHO consumption during exercise, CHO attenuated post exercise increases in blood neutrophils counts, and plasma cortisol and epinephrine but not NK

cell count, or NK cell activity and lymphocyte proliferation.<sup>46</sup> A study by Nieman et al. found that drinking a CHO beverage every 15 minutes while running for 2.5 hours had a significant effect on the pattern of changes in glucose, cortisol, and the blood concentration of NK cells, but not NK cell activity.<sup>48</sup> Likewise in a study by Nehlsen-Cannaralla et al they observed the effects of a CHO beverage compared to a placebo and saw no significant differences in SIgA concentrations. Though few studies have performed post race nutritional interventions, they have found similar results. Costa et al found that ingesting CHO with PRO immediately after prolonged exercise reduces neutrophil degranulation but does not alter cortisol, epinephrine, and norepinephrine levels, leukocyte proliferation, or SIgA response.<sup>49</sup> It was also found that ingesting CHO-PRO immediately after exercise had a greater impact when compared to 1 hour post exercise.

### **Summary of the Literature**

Research suggests that intense, prolonged exercise has a negative impact on the body's immune system. The physiological changes that occur during and post ultra-endurance events have been shown by various research studies. As a result it is believed that after ultra-endurance events athletes experience the following: An immediate increase in leukocyte count, which then decreases below pre exercising levels for several hours post-exercises<sup>9,10,11</sup>; decreases in SIgA concentraion<sup>28,25,26,28</sup>; and decreases in neutrophil and NK cell activity and function<sup>15,16,17,18</sup> but none of these studies reported the incidence or severity of URTI symptoms.

Many nutritional interventions have been observed but CHO ingestion had the most consistent results. However there are gaps in the current literature in regards to



the optimal time to consume CHO. Though it has been found that CHO and PRO consumption has significant impacts on several immune indices. For example, Nieman et al found that ingesting a glucose-containing drink post exercise increased plasma glucose, decreased plasma cortisol and growth hormone concentrations but there was no effect on SIgA. Little research has focused on whether CHO and PRO consumption actually reduces the incidence of URTI symptoms. Further research should aim to determine if a post race nutritional supplementation containing CHO and PRO would reduce the incidence and severity of URTI symptoms.

## Introduction

Numerous elite Ironman tri-athletes compete in several Ironman races during the triathlon season. For months these tri-athletes look to make the most of each training session in order to optimize performance on race day. As a result many tri-athletes look to speed up their recovery between races, so that they may return to training.

One obstacle faced by ultra endurance athletes during the recovery process is the incidence of URTIs. A majority of research focusing on the incidence and severity of URTI symptoms post competition are studies of one-event endurance athletes, such as marathons. To date, research has not focused on URTI symptoms in Ironman tri-athletes.

Many studies have looked at pre race and during race nutritional interventions and supplementations in various types of endurance athletes. Many pre race supplementations remain inconclusive, whereas supplements consumed during the race (particularly those involving CHO) have been shown beneficial. The question remains, if an athlete is nutrient deficit pre race or during the race is it too late to overcome these circumstances post race? Little research has looked at the effects of a post race nutritional supplementation on the incidence and severity of URTIs. Supplementations looking specifically at the combination of CHO and PRO ingestion remain inconclusive especially in regards to the benefits of PRO ingestion. Therefore the purpose of the present study was to examine the effects of a post race nutritional supplementation on the incidence and severity of URTI symptoms after an Ironman Triathlon.

## Methods

### *Study Design:*

The current study was an observational, and a semi-interventional field study that took place at the 2013 Lake Placid Ironman Triathlon. Data was collected over five time points. Baseline (BASE) data collection occurred one day before the race on July 27, 2013 between the hours of 7:00 to 10:30 am. On race day, July 28, 2013 data was collected pre race (PRE), immediately post race (1POST), and three hours post race (3POST). The last day of on-site data collection occurred on July 29, 2013 the morning after the race (AMPOST) between the hours of 7:00 to 10:30 am. To eliminate the variance in regards to time sensitive saliva samples subjects' BASE and AMPOST data collections were scheduled at the same time on each given day. For two weeks following the race, subjects were required to answer an online survey to report any incidence of URTI symptoms.

### *Subject Recruitment:*

Subject recruitment started two months before the 2013 Lake Placid Ironman Triathlon (May and June 2013). A recruitment flyer was posted on the training forum of slowtwitch.com. When an interested tri-athlete contacted the research team, a follow-up email was sent to brief the subject. Briefing sessions were done over email due to the various locations of these athletes around the country. An informed consent form was emailed to subjects interested in participating. Subjects returned these prior to or upon arrival to the race venue. This method recruited 13 subjects, 20 additional subjects were recruited on-site two days before the race at the Lake Placid Ironman Expo.

### *Subject Population:*

Screening information was obtained via medical history questionnaires to ensure that subjects met the study's inclusion criteria. To be included in the study subjects must have been registered for the 2013 Lake Placid Ironman Triathlon and planned to finish in thirteen hours or less. Subjects were healthy individuals with no chronic health problems or history of cardiovascular, metabolic, or respiratory disease. Participants were excluded if they had food allergies or intolerances, including but not limited to, lactose, milk proteins, nuts, and gluten (self-reported). Subjects were not permitted to participate if they that had experienced an exertional heat stroke within the past three years, were pregnant (self-reported), or were on a restricted diet that largely deviated from their normal dietary practices.

### *Data Collection:*

During BASE data collection subject demographics were obtained via medical and training history questionnaires. All subjects were asked to provide a small urine sample to assess hydration status via urine color and urine specific gravity. Urine color was determined using a scaled urine color chart (range 1-8: 1 being light yellow, 8 being brown) developed by *Human Hydration, LLC* (Hampton, VA). Urine specific gravity was measured on site using an *ATAGO A300CL Clinical* refractometer (Bellevue, WA). Once the subjects voided their bladder minimizing excess water weight, body mass was collected. BASE and PRE body masses were used as a hydration status indicator throughout the remainder of the study in addition to urine measures. After body mass was collected the height was recorded for each subject in centimeters. Once height was measured a member of the research team performed a 3-site skin fold assessment via

hand held Lange Skinfold Calipers (Santa Cruz, CA). Subjects were asked to provide a saliva sample. Prior to their arrival subjects were asked to avoid any food intake, consumption of hot fluids, and avoid brushing their teeth within 30 minutes of data collection. In order to collect saliva samples, subjects were required to sit with minimal distractions for ten minutes. Once the ten minutes expired subjects were asked to passively drool using a saliva collection aid (*Salimetrics*, State College, PA) into a 2.0 mL graduated free standing screw cap microcentrifuge tube (*Fisher Scientific*, Pittsburg, PA). Researchers used stop watches to measure secretion rates for each subject. All saliva samples were immediately frozen on site and kept in dry ice until analysis

During PRE data collection all physiological measures (urine color, USG, body mass, and saliva sample) were collected. In addition subjects were asked to record a 24-hour diet record from the previous day. Subjects were instructed and educated on how to be as specific as possible with brand names and serving sizes to account for caloric and macronutrient intake. Registered dietitians reviewed all diet logs with subjects to ensure each record was accurate.

The study had no interference with the athletes during their race. While subjects were racing, wet blub glove temperature (WBGT) and wind speed readings were taken periodically to identify any drastic changes in environmental conditions.

Upon finishing the race, subjects were assigned to either the control (CON, n=18) or intervention group (INT, n=15). Groups were randomly assigned by finish ordering, so that every other subject would be assigned to the control group. This helped create homologous groups based on ability and race performance.

During 1POST and 3POST data collection all physiological measures were taken. While physiological measures were being taken during 1POST data collection, registered dietitians met with each subject to record all energy consumed during the race. During both 1POST and 3POST the INT group was asked to consume two commercial recovery shakes at each time point for a total of four shakes. Each shake consisted of 270 kcal, 45g of CHO, 20g of PRO, and 1g of fat in 11 fl oz bottles. The supplementation of the four recovery shakes resulted in an additional intake of 1,080 kcal, 180g of CHO, 80g of PRO and 4g of fat for each subject in the INT group. Subjects in the CON group were asked to eat and drink as they would normally after completing an Ironman triathlon. There was no nutritional influence on subjects in either group between data collection time points.

During AMPOST data collection all physiological measures were collected in addition with a diet record that consisted of any energy intake post race including breakfast that morning. Registered dietitians reviewed all diet records before subjects left the research team.

#### *Wisconsin Upper Respiratory Symptom Survey (WURSS-21)*

Due to the various locations of the subjects an online survey was used to monitor the subjects' incidence and severity of upper respiratory tract infection symptoms for two weeks post race (July 29, 2013 to August 11, 2013). Surveys were sent via email everyday for the first week post race, and every other day for the second week post race. This gave the research team data points for 1-7 days post race and 8,10, 12, and 14 days post race (11 data points post race in total).

The Wisconsin Upper Respiratory Symptom Survey (WURSS-21) was used to monitor symptom incidence and severity and involved questions pertaining to the subject's health and wellbeing. The WURSS-21 included 1 global severity question (How sick to you feel today? 0 not at all, 1 very mild - 7 severe), 10 symptom-based questions (runny nose, plugged nose, sneezing, sore throat, scratchy throat, cough, hoarseness, head congestion, chest congestion, and feeling tired), 9 functional impairment/quality-of-life questions (think clearly, sleep well, breathe easily, exercise, accomplish daily activities, work outside the home, work inside the home, interact with others, and live your personal life), and 1 global change question (How do you feel compared to yesterday? 1 very much better, 4 the same, 7 very much worse). An overall severity score was calculated by summing the URTI global severity ratings collected each day (0 = not sick, 1 = very mild URTI to 7 = severe).<sup>50</sup> The overall URTI symptom score for the 11-day period was calculated by summing all 10 symptom ratings for each day (0 = do not have this symptom, 1 = very mild to 7 = severe). In similar fashion, the URTI functional impairment/quality-of-life score for the 11-day period was calculated by summing all 9 functional scores for each day (0 = do not have this symptom, 1 = very mild to 7 = severe).<sup>50</sup>

URTIs were counted if a subject scored a 1 or higher on the global severity question (how sick to you feel today) for two or more consecutive days.<sup>51</sup> Any subject who met the URTI criteria was considered symptomatic. Over the eleven time points subjects were divided into either symptomatic (SYM) or asymptomatic (ASYM) groups. (SYM n= 13; ASYM= 20) One subject experienced two separate URTIs in the two weeks post race, which brings the total of URTIs to fourteen.

### *Salivary Immunoglobulin A Analysis:*

Once all field data was collected the frozen saliva samples were transported back to the University of Connecticut. Samples were stored at  $-80^{\circ}\text{C}$  until analyzed for salivary immunoglobulin A (SIgA). To assess SIgA the research team used a Salivary Secretory IgA Enzyme Immunoassay Kit from *Salimetrics* (State College, PA). In order to assess SIgA concentrations all saliva samples were brought to room temperature and diluted (25 $\mu\text{L}$  of saliva to 100 $\mu\text{L}$  of diluent). Samples were then mixed with 50 $\mu\text{L}$  of diluted anti-body enzyme conjugate (25 $\mu\text{L}$  of conjugate and 3mL of diluent) and incubated for 90 minutes. After the 90 minutes expired, 50 $\mu\text{L}$  of the sample and conjugate mixture were added to a microtitre plate then incubated at room temperature with continuous mixing at 400rpm for 90 minutes. After incubation each plate was washed 6 times with the wash buffer after which 50 $\mu\text{L}$  of TMB solution was added to each well. Each plate was placed on a plate rotator for 5 minutes at 500 rpm and then incubated in a dark room for an additional 40 minutes. Once incubation was complete 50 $\mu\text{L}$  of stop solution was added to each well, then the plates were rotated for 3 minutes at 500 rpm. Lastly each plate was placed on a plate reader and read at 450 nm to measure the amount of light absorbed in each well. To calculate the SIgA concentrations the research team used Prism by GraphPad (La Jolla, CA), which the averaged absorbance of each sample and placed it into a fit nonlinear regression one-phase decay equation.

### *Energy Intake and Expenditure*

To account for all caloric and macronutrient intake pre, during and post race diet records were reviewed by registered dietitians and entered into the nutritional analysis



software *Esha* (Salem, OR). Once all calories and macronutrients were accounted for the research team went on to estimate the amount of energy expended during the race. The purpose was to observe changes in energy balance throughout the study. To do this researchers used validated equations to calculate the energy expenditure for each portion of the race (swim, bike and run).

An equation adapted from the *ACSM's Guidelines for Exercise Testing and Prescription*<sup>52</sup> was used to calculate each individual's energy expenditure during the swim  $\{((\text{METs} \times \text{Body Mass (kg)} \times 3.5) / 200) \times \text{Time (minutes)}\}$ . 10 METs were multiplied by the subjects' body mass, which was then multiplied by the amount of time it took to complete the swim portion of the race. When determining the number of METs the research team looked to Heyward's *Advanced Fitness Assessment and Exercise Prescription* where swimming freestyle, fast and at a vigorous effort was considered 10 METs.<sup>53</sup> All subjects swam in wetsuits, which reduces body density and increases swim efficiency reducing calorie expenditure. Based on results found by Cordain and Kopriva it was estimated that 1-3 seconds / 60m were saved over a 2.4 mile swim therefore the research team applied an 80 calorie correction factor (subtracting 80 kcals from the total kcals burned during the swim).<sup>54</sup>

The same equation used for the swim was applied to the bike portion of the race. METs were determined by a subject's average speed. To determine each subject's average speed (mph) the distance (112 miles) was divided by the amount time (hours) it took to complete this portion of the race. The METs were either 12 (defined as bicycling at 16 -19mph) or 16 (defined as bicycling  $\geq$  20mph). The METs were then multiplied by the subject's body mass to calculate calories burned per minute, which was then

multiplied by the time in minutes to produce the total number of calories burned during the bike portion of the race.

To determine the calories expended during the run the research team used an equation adapted from the *ACSM's Guidelines for Exercise Testing and Prescription*.<sup>52</sup> When calculating the energy expenditure for the run the research team had to take elevation changes into account. As result the running course was divided into uphill, downhill and flat sections. Knowing that all subjects ran 26.2 miles (42,165m), the research team calculated the percentage of the race spent in each section (52.3% uphill, 25.3% downhill, 22.4% flat). Overall run time was multiplied by these percentages to estimate the amount of time spent in each section. The average speed for each section was calculated by dividing the distance traveled in meters by the time in minutes. When calculating the energy expenditure during the uphill sections of the race a weighted average grade of 2.56% was used compared to a 1.0% grade for the flat and downhill sections. Running downhill increased run efficiency reducing calorie expenditure therefore the research team corrected this by subtracting 10kcal for every mile spent running downhill (65.5 kcal). Average speed and grade was used to calculate individual  $\text{VO}_2$ s for each subject during the different sections of the run. To determine calories burned per minute each subject's  $\text{VO}_2$  was multiplied by their body mass then divided by 1,000. The calories per minute were then multiplied by the time spent in each section. All calories from each section were summed to find the total energy expenditure for the run portion of the race.

During post-hoc analysis the research team estimated the amount calories each subject expended the day prior to the race. The resting metabolic rates (RMR) were

calculated for each subject using the Cunningham equation. This equation was found to most accurately predict RMR in elite endurance athletes.<sup>55</sup> The Cunningham equation only requires knowledge of an individual's lean body mass  $\{500 + 22(\text{lean body mass in kilograms})\}$ . At baseline each subject's body fat percentage was calculated using a 3-site skin fold assessment. The body fat percentage was subtracted from 100 to determine the amount of lean body mass in each subject. The research team also had to take into account the thermal effect of food, which was estimated to be 10% of the caloric intake that day. Lastly it was assumed that subjects were fairly sedentary the day before the race therefore the estimated caloric expenditure for physical activity was low (between 350-600kcal). PRE energy expenditure was compared to PRE energy intake to observe preparation strategies and behaviors.

#### *Statistical Analysis:*

A one-way ANOVA compared overall symptom scores, overall severity scores, overall function impairment scores, energy intake, energy expended and SIgA concentrations between INT and CON groups, as well as SYM versus ASYM groups. 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.

## Results

### *Subject Demographics:*

Thirty-three Ironman tri-athletes (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; weight:  $76.3 \pm 10.4$ kg; body fat:  $10.80 \pm 3.79\%$ ) participated in the present study. Subjects were all Ironman tri-athletes who trained on average  $15 \pm 4$  hours per week and had an overall average finish time of  $686 \pm 152$  minutes.

### *Environmental Conditions*

Environmental measures were taken periodically through the race on July 28, 2013. The temperatures were mild with a high of  $71.0^{\circ}\text{F}$  ( $21.7^{\circ}\text{C}$ ) and low of  $60.0^{\circ}\text{F}$  ( $15.6^{\circ}\text{C}$ ), partly cloudy to overcast conditions with periodic rain showers. (Table 4)

**Table 4: Average Environmental Conditions: July 28, 2013 Lake Placid NY**

Time of Day	Air Speed km/hr	Dry Bulb $^{\circ}\text{C}$	Wet Bulb $^{\circ}\text{C}$	Humidity %	Heat Index $^{\circ}\text{C}$	Globe Temperature $^{\circ}\text{C}$	WBGT $^{\circ}\text{C}$
7:30	0	18.3	18	76.9	21.3	20.1	18.9
10:00	1.3	20.6	18.9	77.8	20.8	23.3	19.1
12:30	1.4	21.1	18.2	77.5	21.8	23.2	19.3
13:30	2	20.5	17.5	77.3	20.6	22.4	19.2
15:00	0	19	19	74.7	22.6	22.8	20
18:30	1.2	18	17.7	74.6	21	22.8	20.9
22:00	0	16.7	16.1	95.5	17.3	18	16.6
Average	$0.8 \pm 0.8$	$19.2 \pm 1.6$	$17.9 \pm 1.0$	$79.0 \pm 6.9$	$20.8 \pm 1.7$	$21.8 \pm 2.0$	$19.1 \pm 1.3$

## Nutrition

There were no significant differences between the caloric intake the day before the race ( $p = 0.462$ ), the day of the race ( $p = 0.510$ ), during the race ( $p = 0.102$ ) or post race ( $p = 0.951$ ). (Figure 10)

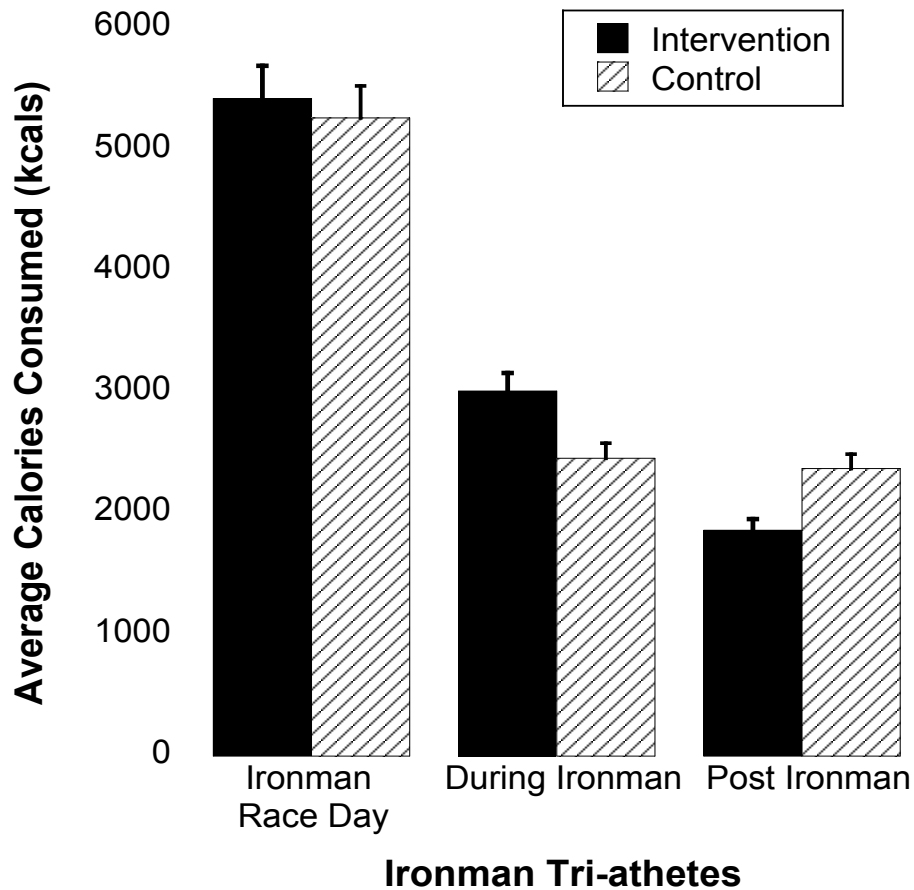


Figure 10: Average caloric intake on day of an Ironman Triathlon.

\*Indicates significance between groups  $p < 0.05$

The research team focused on the three macronutrients carbohydrates (CHO), proteins (PRO), and fats. There were significant differences in race day consumption of CHO and fats ( $p = 0.041$  and  $p = 0.005$  respectively). (Figure 11)

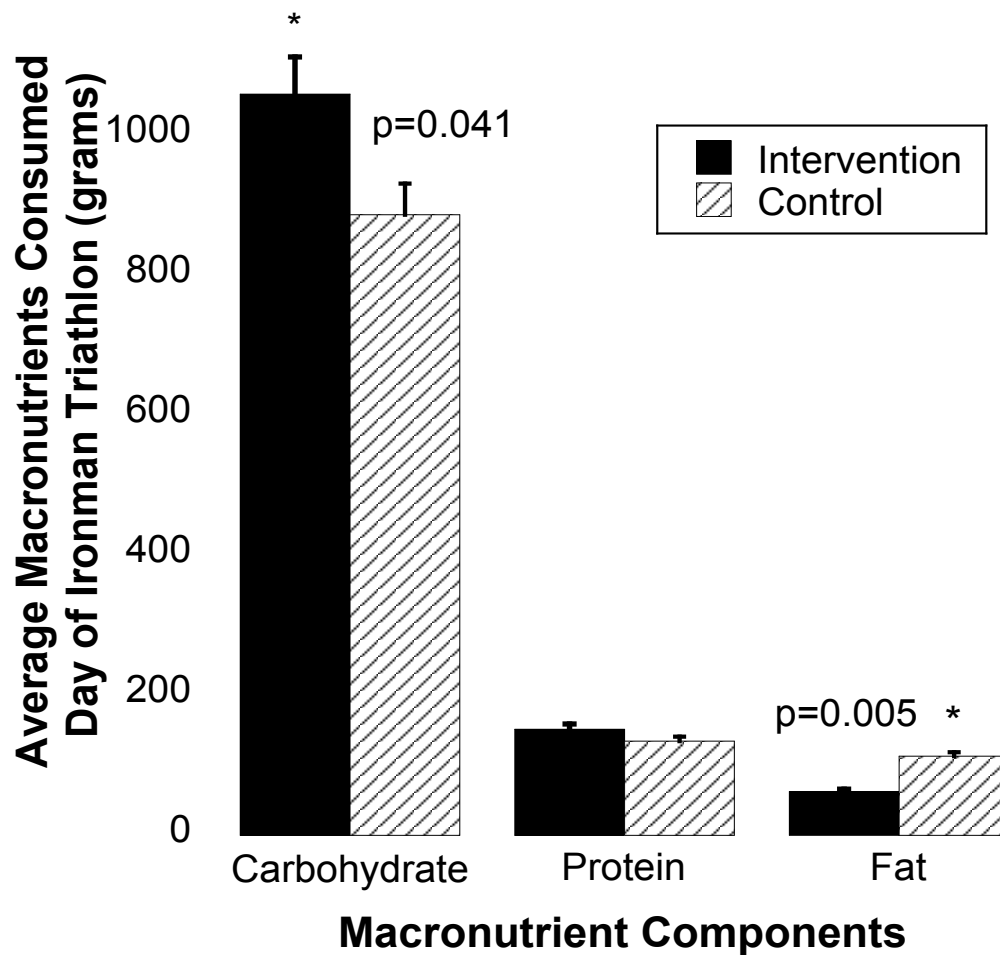


Figure 11: The average macronutrient intake on race day.

\* Indicates significance between groups  $p < 0.05$

During the race the average CHO consumed by the INT group was significantly greater than the CON group ( $p=0.041$ ). (Figure 12) After the race, the average PRO consumed by the INT group was  $111 \pm 18$  compared to  $74 \pm 47$  consumed by the CON group ( $p=0.006$ ). (Figure 13)

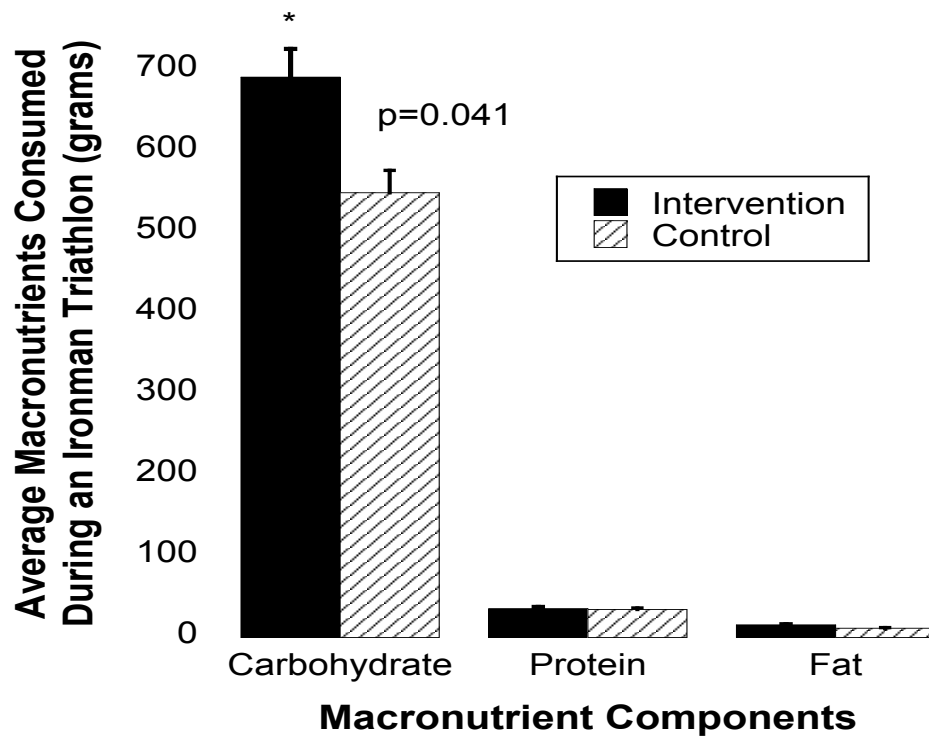


Figure 12: Average macronutrient intake during an Ironman Triathlon.  
 \*Indicates significance between groups p<0.05

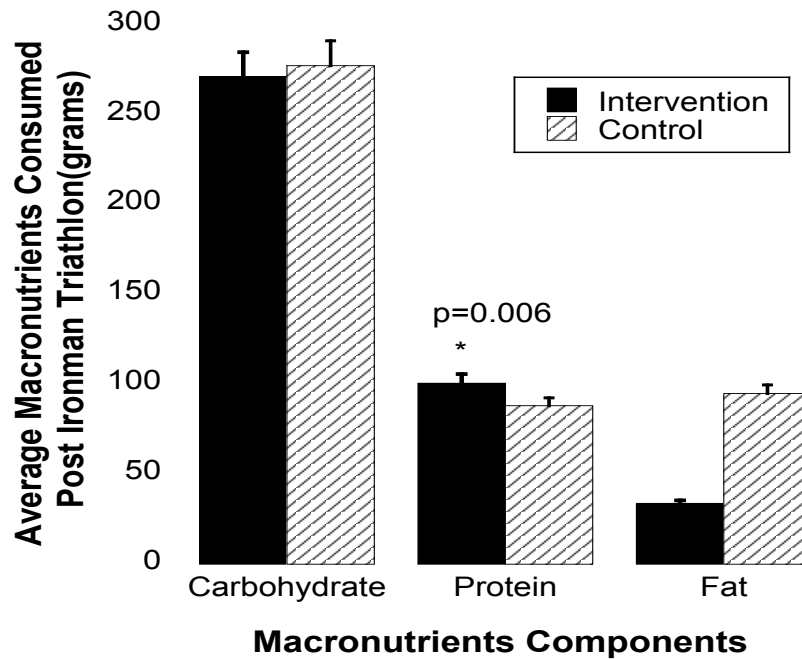


Figure 13: Average macronutrient intake post an Ironman Triathlon.  
 \*Indicates significance between groups p<0.05

	Overall Symptom Score	Overall Function Score	Overall Severity Score	Hours Trained	Post Race caloric Intake	Post Race Protein	Post Race Carbohydrate	Post Race Fat	SlgA BASE	SlgA AMPOST
Overall Symptom Score	1	.234	.798**	.511**	.037	.103	.064	-.051	.300	.105
Overall Function Score		1	.319	.216	-.218	-.219	-.219	-.122	-.128	-.056
Overall Severity Score			1	-.452**	-.088	.049	-.023	-.205	.407*	.109
Hours Trained				1	.029	.037	.150	-.100	.203	.399*
Post Race caloric Intake					1	.762**	.893**	.840**	.109	.176
Post Race Protein						1	.655**	.513**	.152	.129
Post Race Carbohydrate							1	.552**	.114	.344*
Post Race Fat								1	.061	.013
SlgA Baseline									1	.414*
SlgA Morning Post										1

\*Correlation is significant at a 0.05 level \*\* Correlation is significant at a 0.01 level; SlgA:Salivary Immunoglobulin A (SlgA) Concentrations



### Calorie Expenditure

After accounting for all energy and macronutrient intake throughout the study, the research team estimated the calories expended to complete an Ironman Triathlon. The average energy expenditure was  $10,186 \pm 1,756$ kcal for the INT group and  $10,804 \pm 1,593$ kcal for the CON group ( $p = 0.052$ ). (Figure 14) When looking at the energy balance during the race the average nutrient deficit (Energy intake during the race – energy expended during the race) was  $7,741 \pm 1620$ kcal.

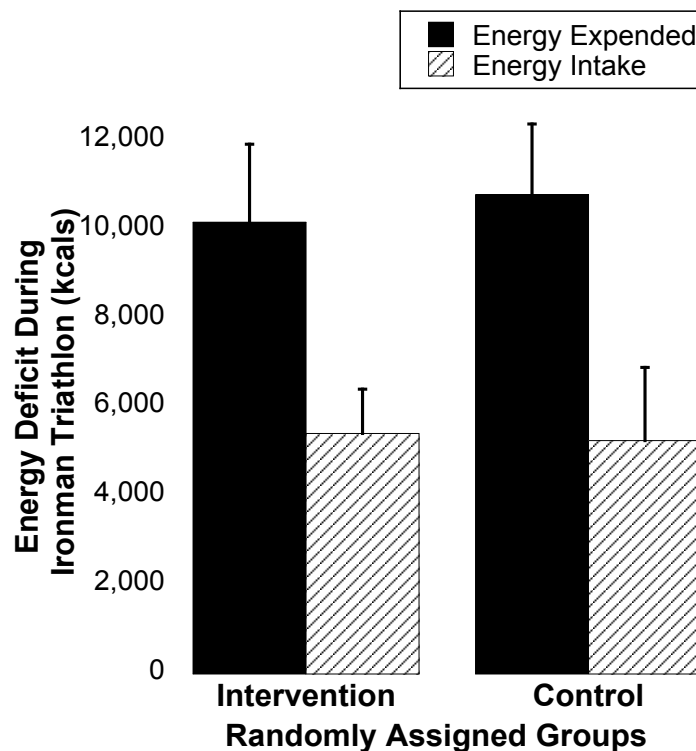


Figure 14: Average energy balance during the race between groups.  $p < 0.05$

Subjects still remained at a nutrient deficit despite energy intake post race. (Figure 15) The average deficit after accounting for post race dietary intake was  $3027 \pm 2702$ kcal. In a post-hoc analysis pre race energy expenditure was compared to pre race energy intake. (Figure 16)

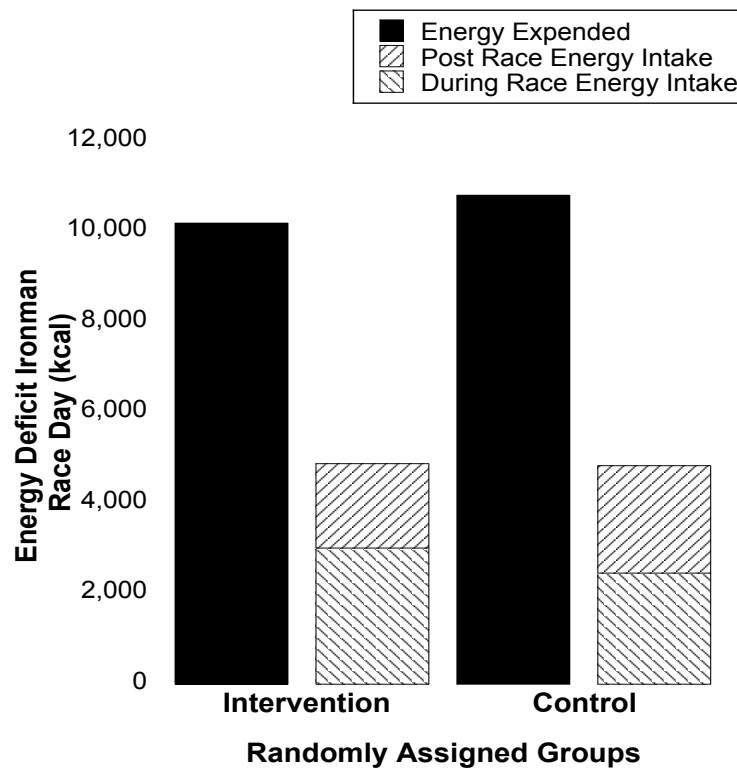


Figure 15: Average energy deficit the day of an Ironman Triathlon.  
 \*Indicated significance between groups  $p < 0.05$

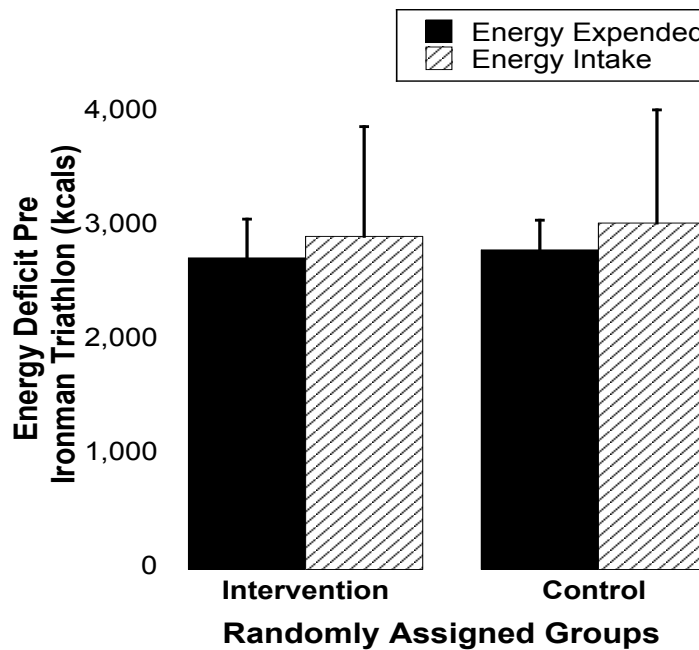


Figure 16: Average energy deficit the day prior to an Ironman Triathlon.  
 \*Indicated significance between groups  $p < 0.05$

### *Incidence and Severity of Upper Respiratory Tract Infection Symptoms*

A cumulative URTI severity score (over 11-time points) could range from 0 to 77. The average URTI severity score for INT group was  $7 \pm 9$  and  $3 \pm 3$  for the CON group ( $p=0.069$ ). The URTI symptom scores had a much greater potential range (0-770) over the 11 time points. The URTI symptom scores for INT and CON groups were  $32 \pm 38$  and  $16 \pm 23$  respectively ( $p=0.155$ ), where as the function/ability scores (potential score range 0 to 693) were  $6 \pm 10$  and  $6 \pm 14$  for the INT and CON groups respectively ( $p=0.799$ ). (Figure 17)

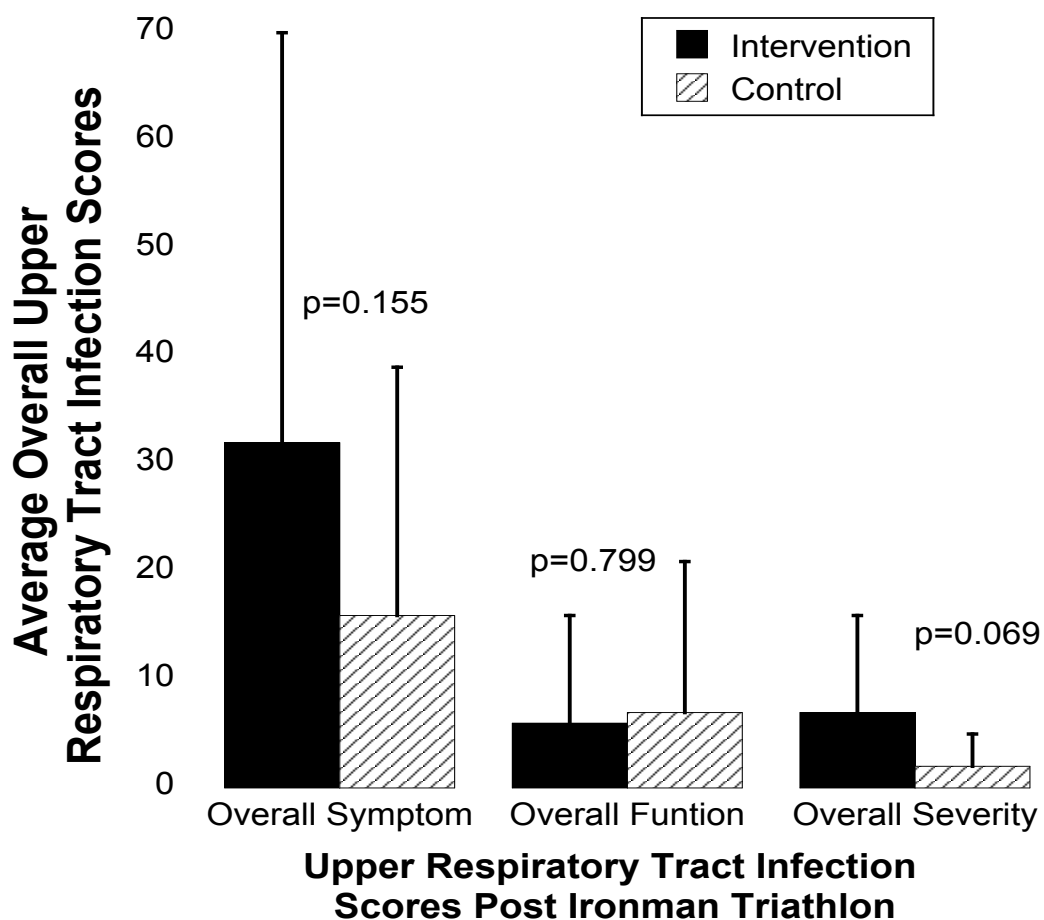


Figure 17: The Average Overall Symptom, Function, and Severity Scores Between Groups

The average URTI symptom score for each day varied in severity and time. Though not significantly different the highest score recorded for the INT occurred one day post race, whereas the CON group experienced their highest score two days post race (Figure 18)

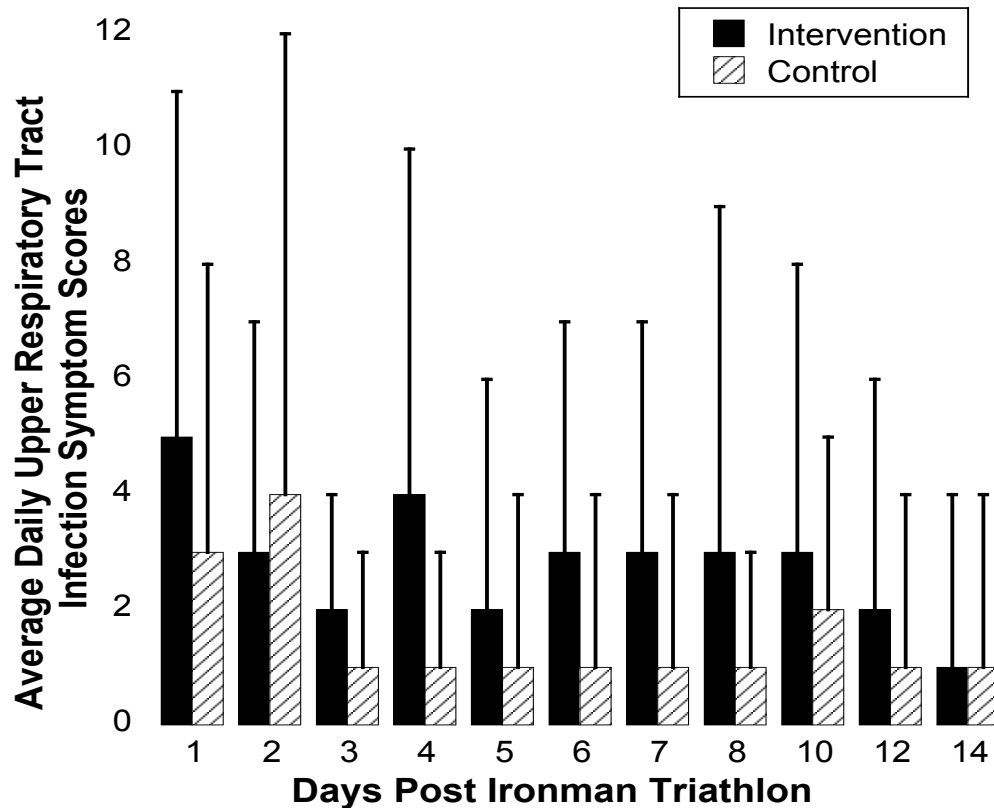


Figure 18: The Average Daily Upper Respiratory Tract Infection Symptom Scores Post Ironman Triathlon

\*Indicates significance between groups  $p < 0.05$

URTIs were self-reported by ranking a 1 or higher on the global severity question for two or more consecutive days.<sup>51</sup> Using this scoring method, fourteen URTIs were reported (One subject in the CON group experienced two separate URTIs). The average severity score of all the URTIs experienced was of  $2 \pm 1$ . The INT and CON groups both had seven reported URTIs with average severity scores of  $2 \pm 0$  for the INT

group, and  $2 \pm 1$  for the CON group. The length of each URTI was inconsistent and varied between each case reported. (Figure 19) The average length of URTIs was  $5 \pm 3$  days. The average length of URTIs experienced in the INT group was significantly greater ( $6 \pm 3$ ) than the CON group ( $3 \pm 1$ ) ( $p=0.022$ ). (Figure 20)

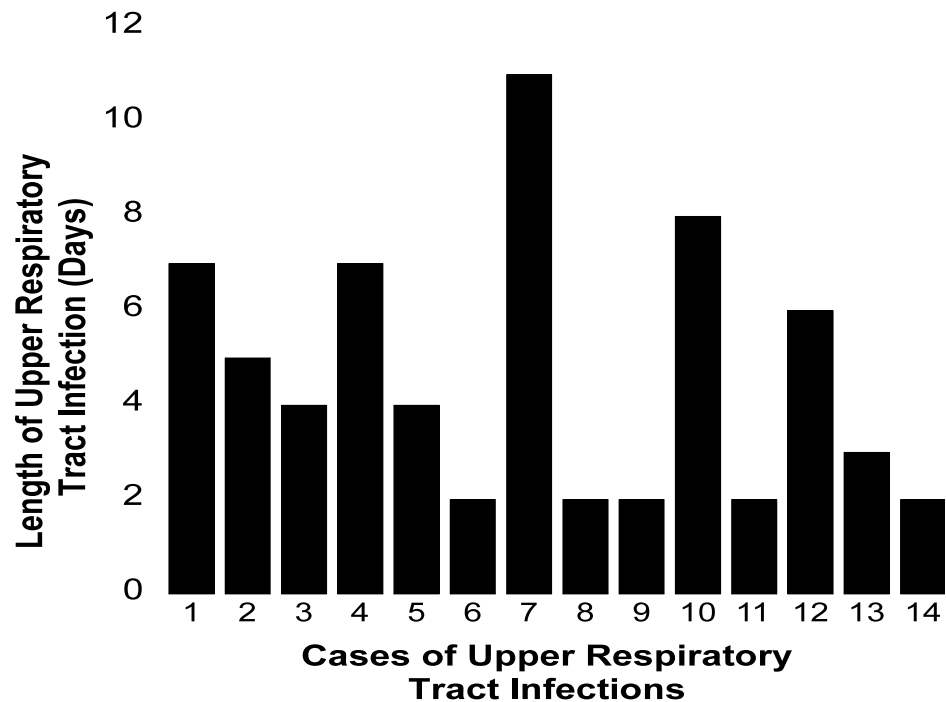


Figure 19: The Variations in Length of Each Reported Upper Respiratory Tract Infection Post Ironman Triathlon

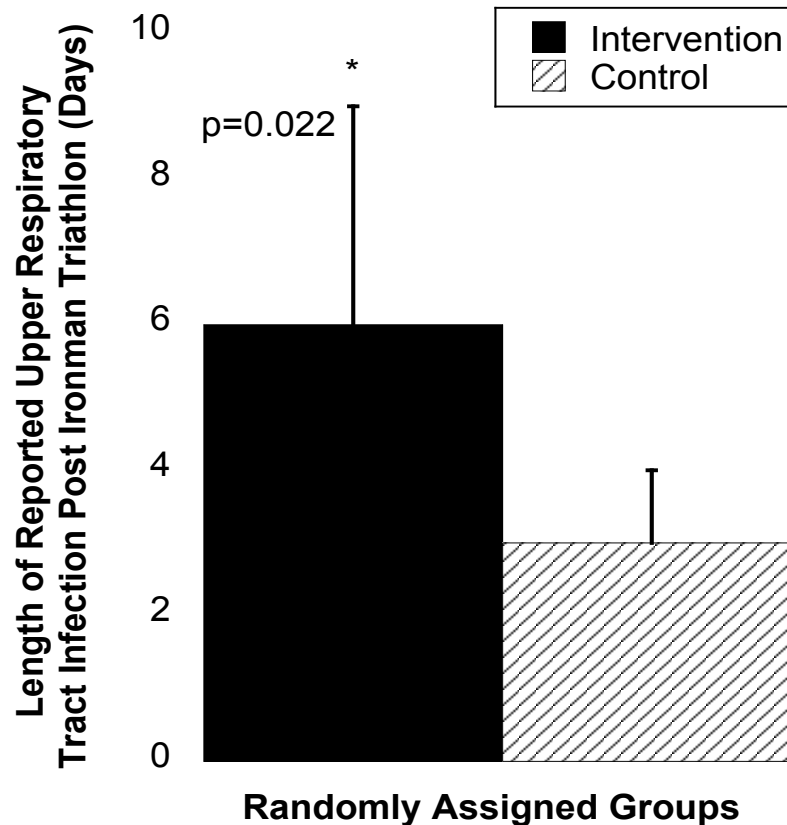
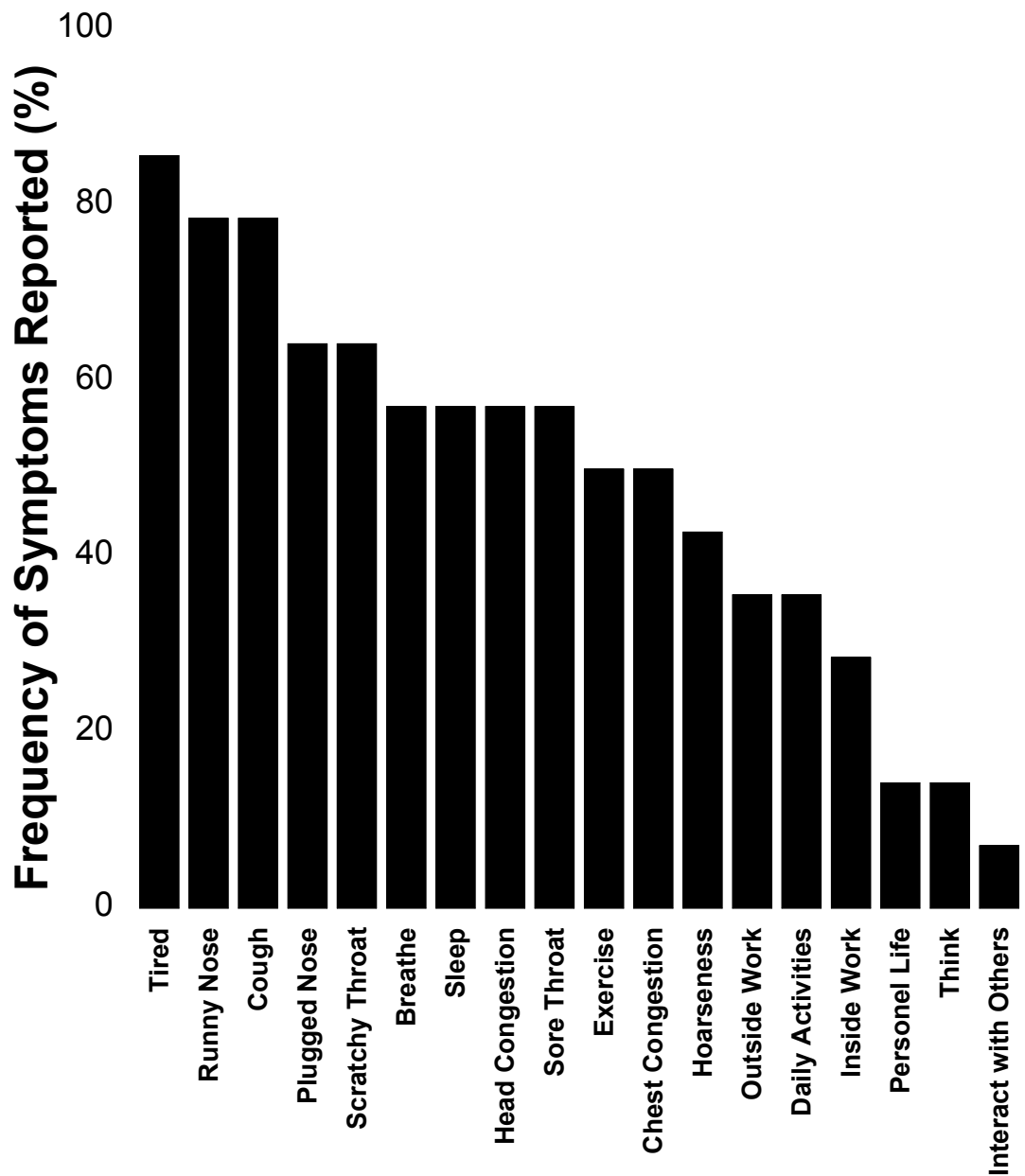


Figure 20: The Average Length of Reported Upper Respiratory Tract Infections Post Ironman Triathlon

\*Indicates significance between groups  $p < 0.05$

Along with the length of time each URTI was experienced, the symptoms associated with each case varied. The most frequent symptom was feeling tired appearing in 86% of all URTIs reported. The next most frequent symptoms were coughing and having a runny nose both occurring in 79% of all URTIs. (Figure 21) Though the average overall severity was low ( $2 \pm 1$ ), the severity and length of each reported case varied greatly among subjects. Some cases experienced more severe symptoms in the beginning stages of their URTIs, some experienced more severe symptoms towards the end of their illness, while for some the severity scores remained the same throughout the URTI. (Figure 22)



### Symptoms Experienced In Reported Upper Respiratory Tract Infections Post Ironman Triathlon

Figure 21: Frequency of Symptoms Experienced in Upper Respiratory Tract Infections Post an Ironman Triathlon

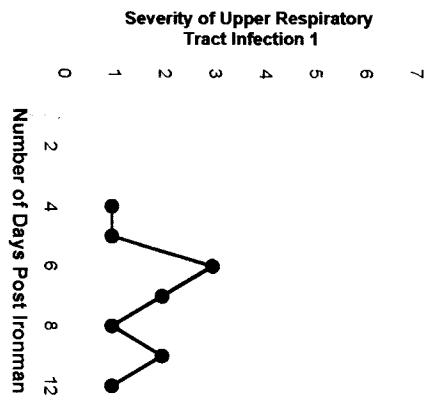


Figure 22a

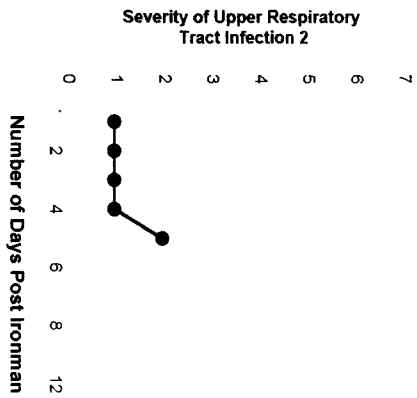


Figure 22b

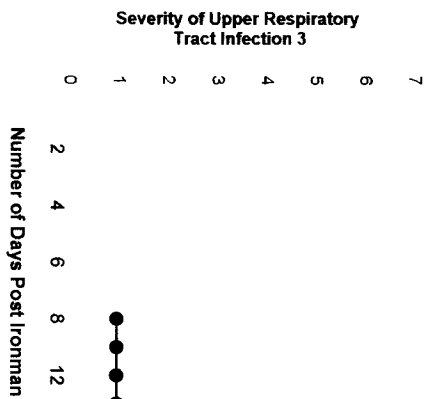


Figure 22c

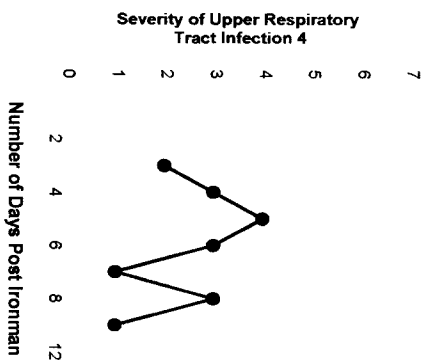


Figure 22d

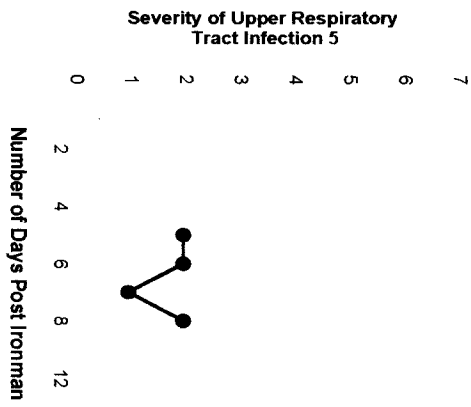


Figure 22e

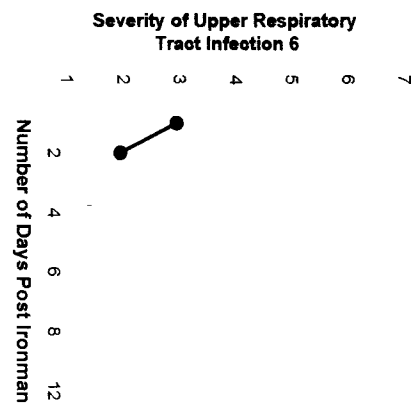


Figure 22f

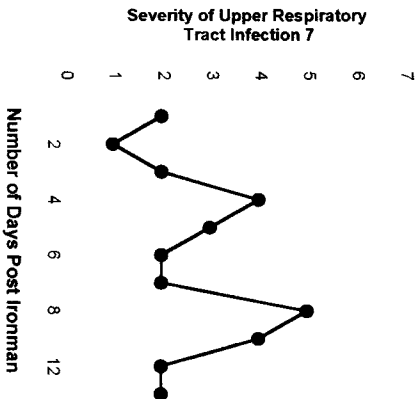


Figure 22g

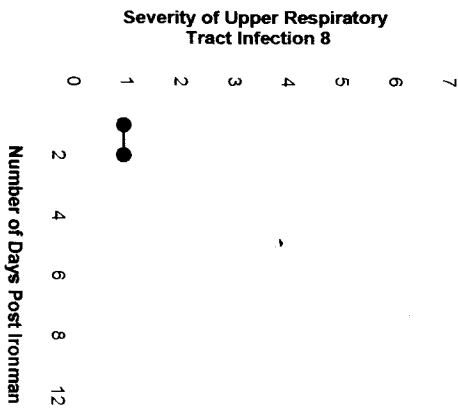


Figure 22h



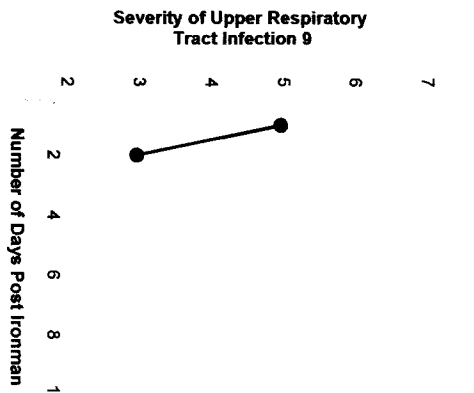


Figure 22i

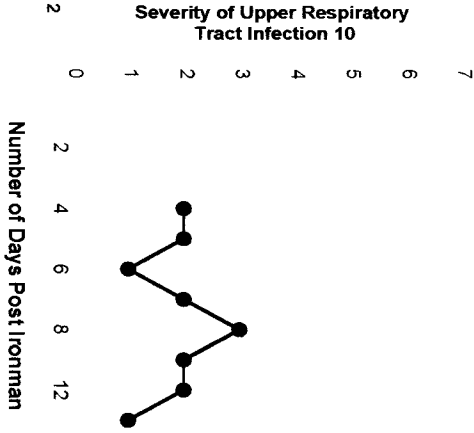


Figure 22j

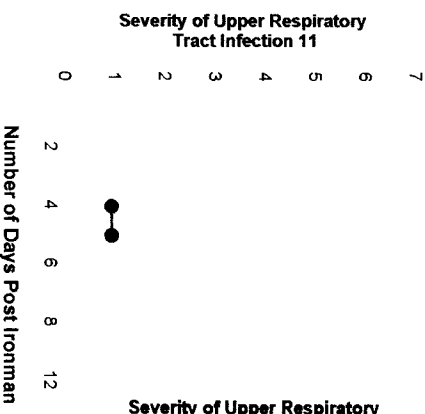


Figure 22k

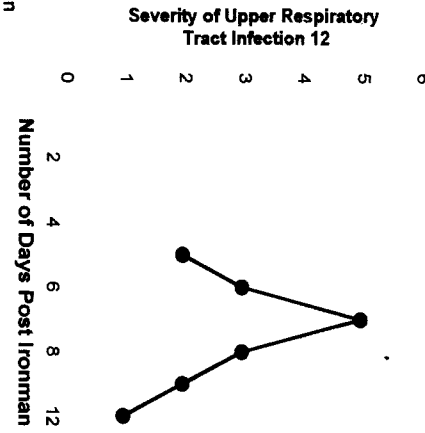


Figure 22l

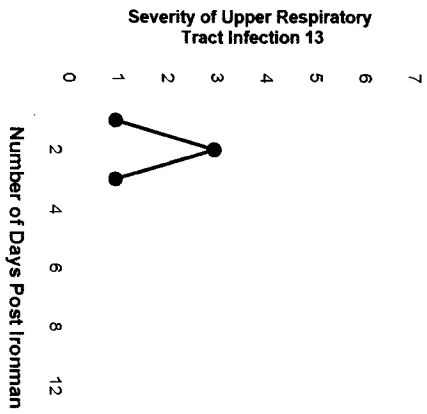


Figure 22m

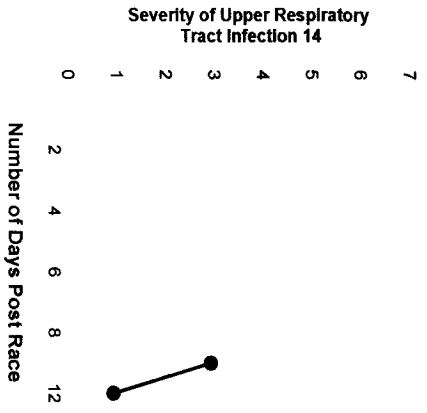


Figure 22n

Figure 22(a-n): The Length and Severity of Each Recorded Upper Respiratory Tract Infection Post an Ironman Triathlon

The overall symptom and overall severity scores were both positively and significantly correlated with average hours trained. (Figure 23 and 24) There were no significant correlations between overall symptom, overall function and overall severity scores with age, finish time, caloric and macronutrient intake, or SIgA concentrations.

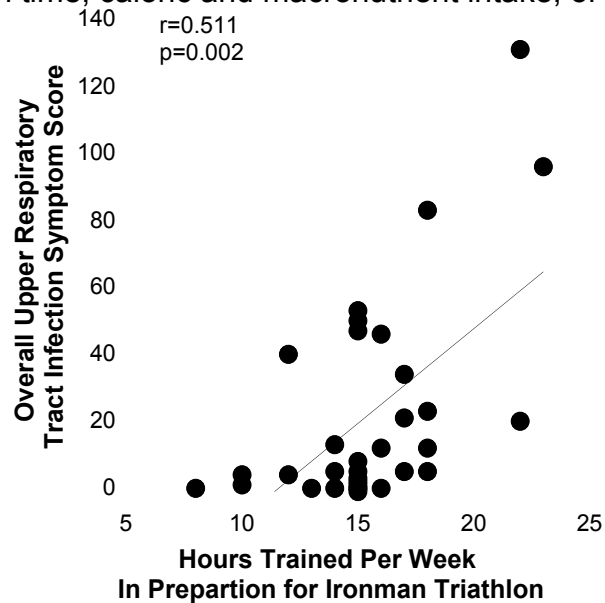


Figure 23: The Correlation Between Overall Upper Respiratory Tract Infection Symptom Score Post Ironman Triathlon and Hours Trained  $p<0.05$

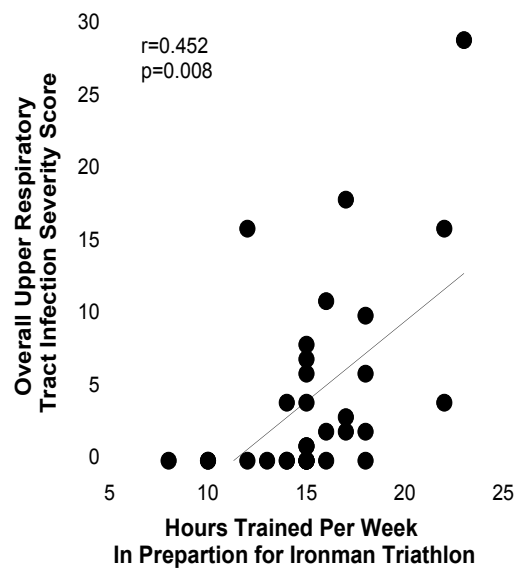


Figure 24: The Correlation Between Overall Upper Respiratory Tract Infection Severity Score Post Ironman and Hours Trained  $p<0.05$

### Salivary Immunoglobulin A (SIgA) Concentrations

The average SIgA concentration for the INT group at BASE and AMPOST ( $48.8 \pm 14.2 \mu\text{g/mL}$  and  $44.8 \pm 15.1 \mu\text{g/mL}$  respectively) were slightly but not significantly ( $p > 0.05$ ) elevated compared to the CON group ( $44.4 \pm 15.5 \mu\text{g/mL}$  at BASE and  $36.9 \pm 25.4 \mu\text{g/mL}$  at AMPOST). (Figure 25) Though the average BASE concentration was slightly elevated ( $46.4 \pm 14.9 \mu\text{g/mL}$ ) compared to the average AMPOST ( $40.5 \pm 21.4 \mu\text{g/mL}$ ) it was not significantly different ( $p = 0.199$ ) AMPOST SIgA concentrations were significantly and positively correlated with hours trained ( $r = 0.399$   $p = 0.022$ ), and with CHO consumed on race day ( $r = .428$   $p = 0.013$ ). SIgA concentrations were positively but not significantly correlated with CHO consumed post race ( $r = 0.344$   $p = 0.05$ ). (Figures 26, 27, and 28)

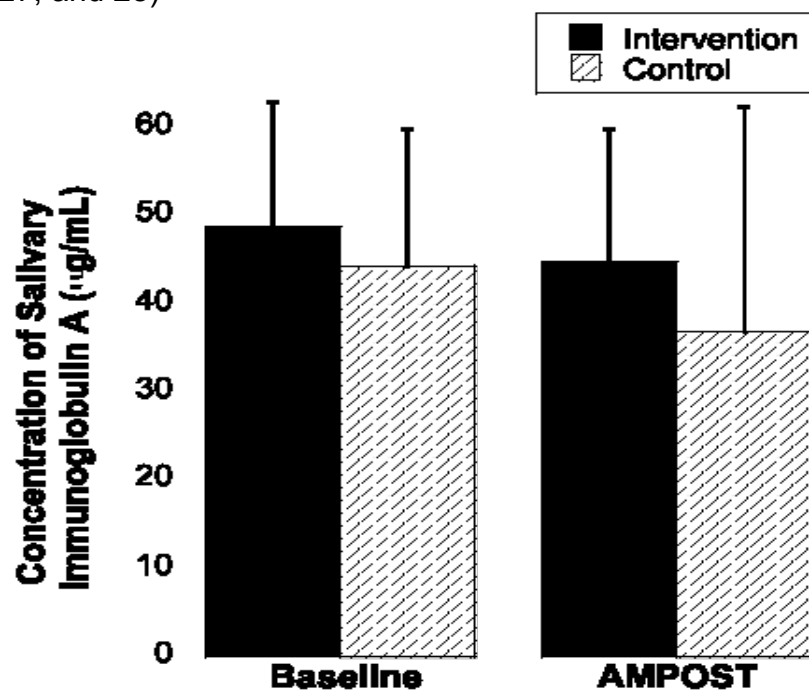


Figure 25: Average salivary immunoglobulin A concentrations  $p < 0.05$

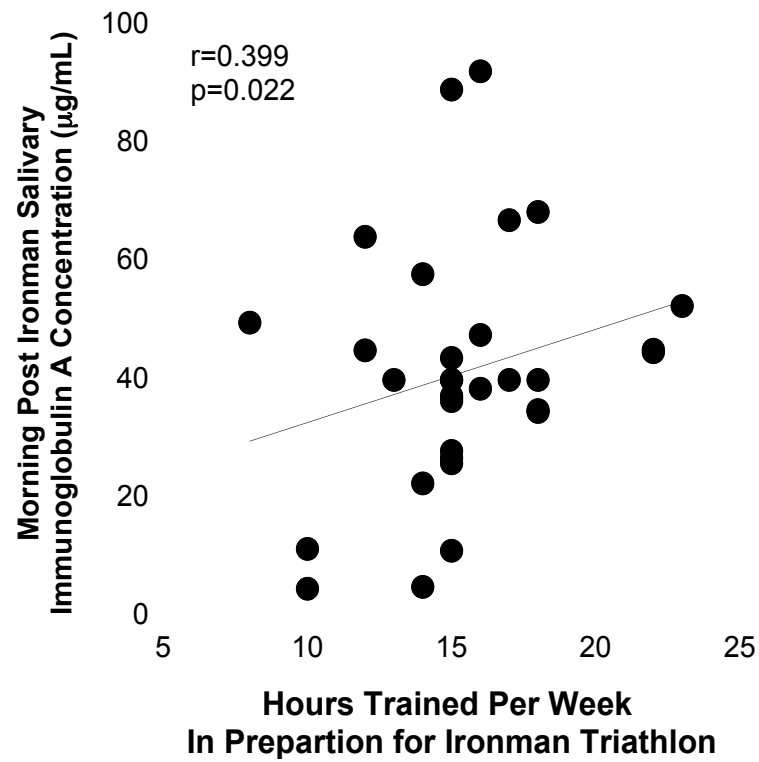


Figure 26: Correlation between morning post Ironman salivary immunoglobulin A concentrations and hours trained  $p<0.05$

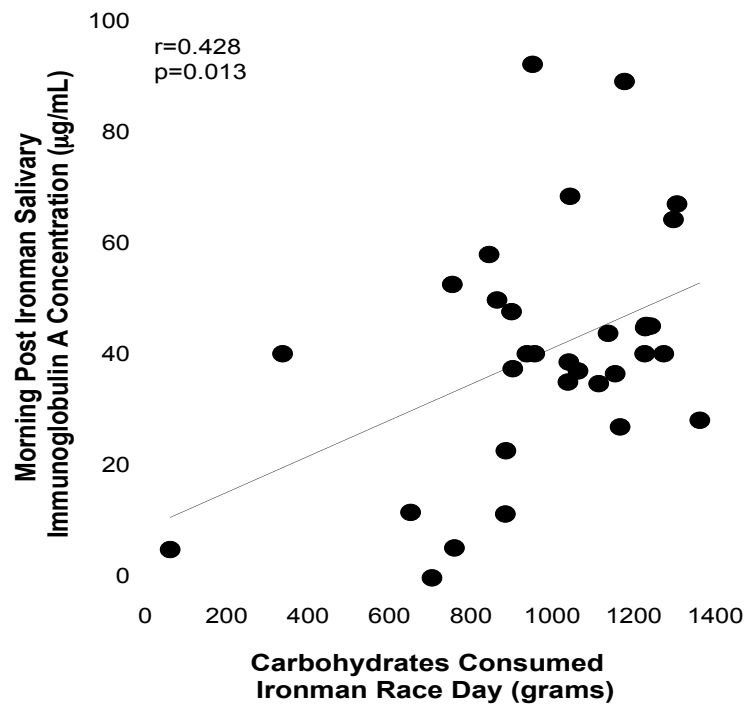


Figure 27: Correlation between morning post Ironman salivary immunoglobulin A concentrations and carbohydrates consumed on race day  $p<0.05$

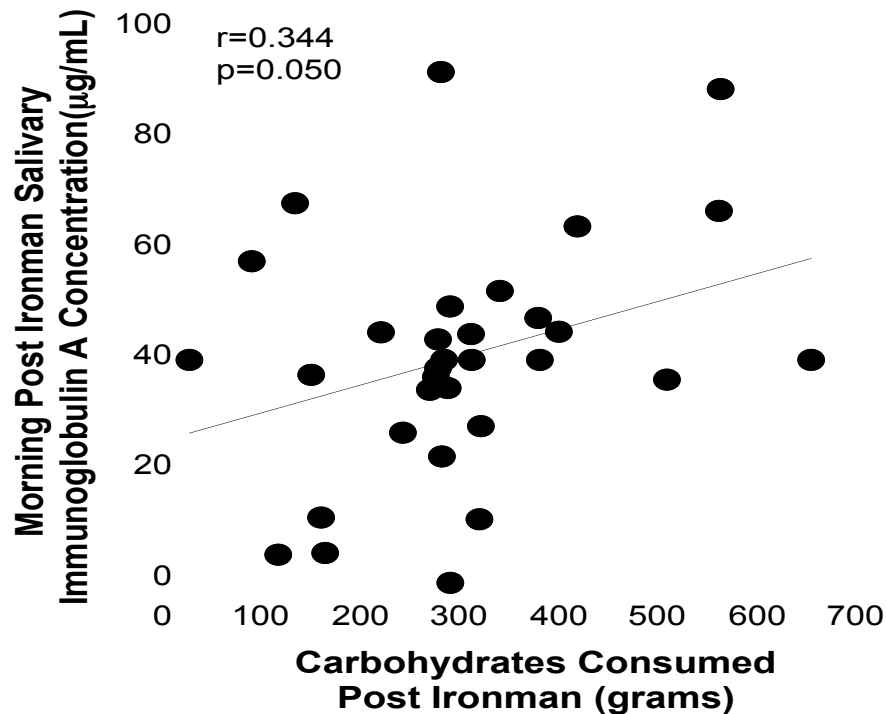


Figure 28: Correlation between morning post Ironman salivary immunoglobulin A concentrations and carbohydrates consumed on post race  $p < 0.05$

#### *Factors Between Symptomatic and Asymptomatic Population*

When comparing SYM subjects versus ASY subjects there were no significant differences between age ( $p = 0.761$ ), hours trained ( $p = 0.076$ ), and ratings of perceived exertion post race ( $p = 0.209$ ). The subject demographics between groups only differed in body fat percentage in which the SYM group had significantly greater values ( $p = 0.004$ ). (Figure 29) The BASE SIgA concentrations were significantly greater in the SYM group ( $p=0.024$ ) but there were no differences in AMPOST SIgA concentrations(Figure 30). Overall race performance was similar for both SYM and ASYM groups, with the only significant difference occurring in bike time ( $p=0.04$ ). (Figure 31)

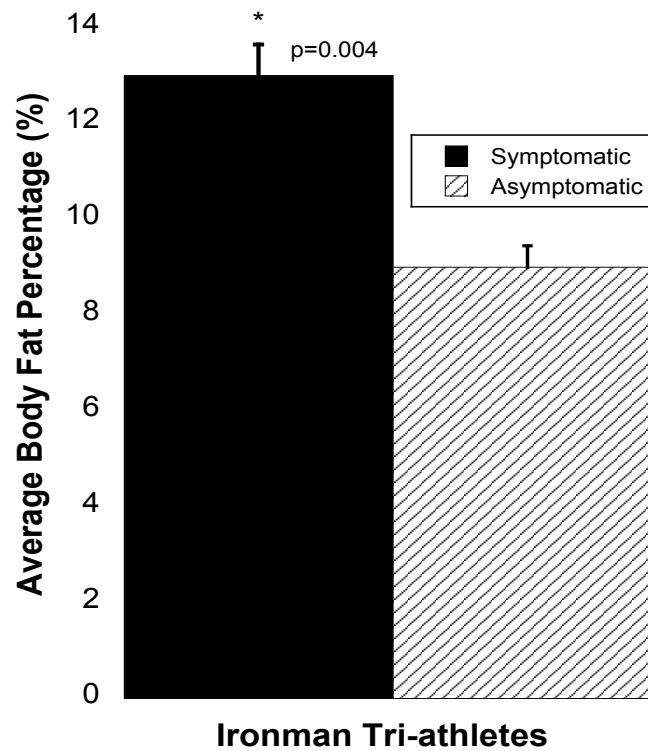


Figure 29: The Average Body Fat Percentage of the Symptomatic vs. Asymptomatic Groups  $p < 0.05$

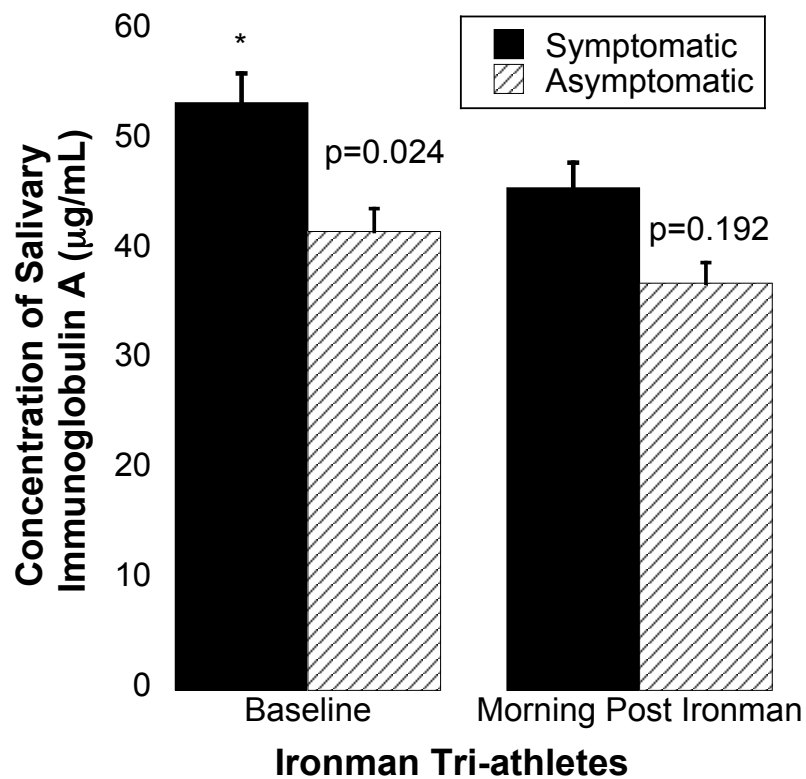


Figure 30: Concentrations of Salivary Immunoglobulin A Symptomatic vs. Asymptomatic Groups  $p < 0.05$

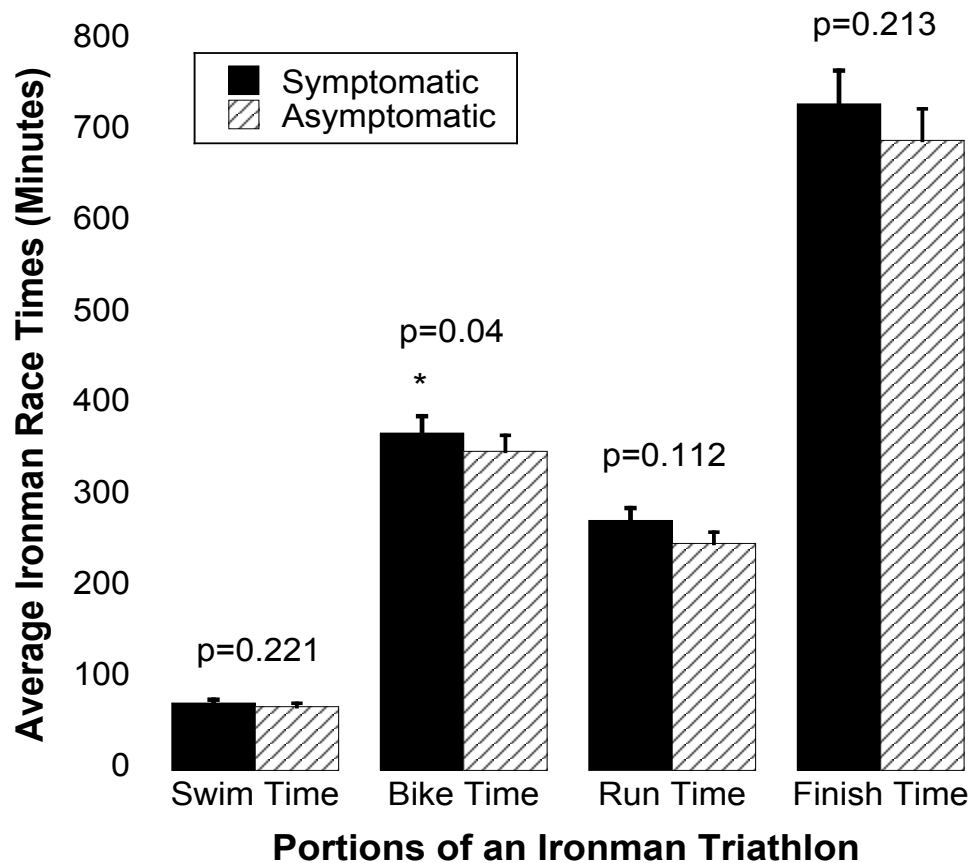


Figure 31: The Average Race Times of the Symptomatic and Asymptomatic Groups.

\*Indicates significance between groups  $p < 0.05$

Energy expended during the race did not vary between groups, but there were significant differences in energy intake. Both SYM and ASYM groups consumed similar kilocalories during the race, but the SYM group consumed significantly less energy the day before the race ( $p=0.031$ ) and post race ( $p=0.008$ ). (Figure 32) The ASYM group consumed a significantly greater amount of CHO the day before the race ( $p=0.032$ ), fat the day of the race ( $p=0.006$ ), CHO post race ( $p=0.08$ ) and fat post race ( $p=0.002$ ). (Figure 33)

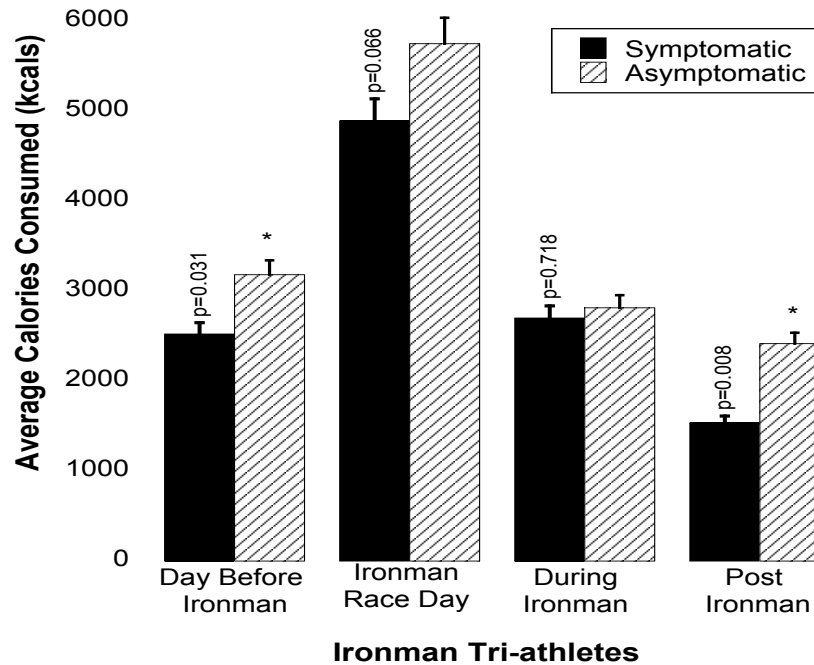


Figure 32: The Average Caloric Intake of the Symptomatic and Asymptomatic Groups the Day Before, the Day of, and Post Ironman  $p < 0.05$

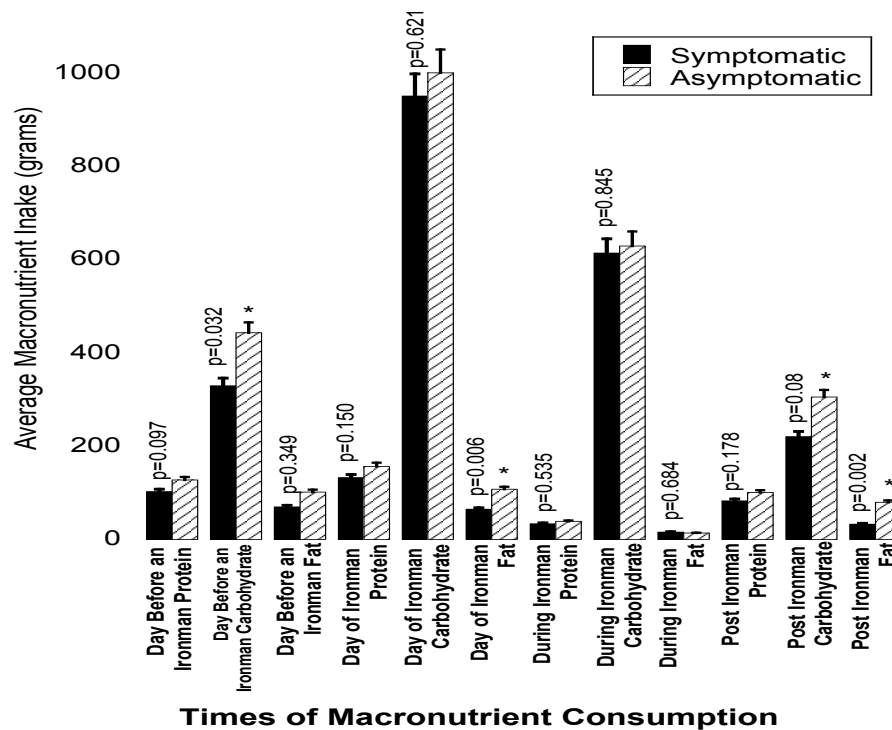


Figure 33: The Average Macronutrient Intake: Symptomatic vs. Asymptomatic Groups the Day Before, the Day of, and Post Ironman  $p < 0.05$



## Discussion

The purpose of the present study was to determine the effects of a post race nutritional supplementation on the incidence and severity of URTIs after an Ironman Triathlon. There were no significant demographic or performance differences between the INT and CON groups. Post race, when the nutritional intervention was consumed, the INT group had a significantly greater amount of PRO consumption while the CON group had a significantly greater amount of fat intake, resulting in similar overall caloric intake post race. Caloric intake between groups was also similar pre and during the race.

The post race nutritional supplementation did not result in a reduction in the incidence or severity of the URTI symptoms, or differences in SIgA concentrations in Ironman tri-athletes. Among all 33 subjects, fourteen URTIs of various lengths and severities were reported within two weeks of competing in the 2013 Lake Placid Ironman Triathlon. Both the INT and CON groups had seven reported URTIs with no significant differences in severity. Those who experienced an URTI in the two weeks post race consumed significantly less kilocalories the day before the race, and post race.

### *Incidence and Severity of Upper Respiratory Tract Infection Symptoms*

URTI symptom severity, overall scores and overall function scores were similar between groups. However, all three URTI indices reported were within the lower 1-10% of the possible score, indicating that all subjects, regardless of group, had very few and minor, if any, URTI symptoms.

In a study by Nieman et al the WURSS-21 (which was also used in the present study) was used to compare the innate immune function responses to intensified exercise in trained long distance runners and cyclists.<sup>50</sup> In Nieman's the severity score in runners was 3.1% of the possible range vs. 2.9% in cyclists after 12 weeks of intensified training. In comparison the current study's INT group severity, symptom and function scores were 9.1%, 4.2%, and 0.87% respectively, while the CON group scores were 3.9%, 2.1% and 0.87% respectively.

The differences in severity percentages indicate that subjects in the present study endured more severe URTI symptoms. This finding may be a result of the length of exercise performed in each study as supported by the J-Curve, in which prolonged exercise increases the risk of URTIs.<sup>4</sup> In Nieman's study subjects exercised for a total of 2.5 hours per day. In the present study subjects raced an average of 11.4 hours. Though there were no correlations in the present study between URTI severity scores and bike, run or finish times, the length and intensity of exercise could assist in explaining the differences in scores reported.

In the current study once a URTI was recorded it was found that each case varied in its severity as well as in its symptoms. The most frequent symptom reported was feeling tired, which occurred in 86% of all URTIs reported. The next most frequent symptoms were coughing and having a runny nose, which both occurred in 79% of all URTIs.

A previous study examining the incidence and frequency of the symptoms presented in the WURSS-21<sup>56</sup> within the general population found that nasal symptoms such as a runny nose were generally the most frequent occurring in 99.6% of URTIs.<sup>56</sup>

Sore and scratchy throats and coughing also had high frequency rates at 97.8%, and 93.5% respectively.<sup>56</sup> Feeling tired or run down was reported in 100% of cases. In regards to functional / impairment symptoms Barrett found breathing easily to be the most effected (95.7%). Other functional / impairments frequencies included think clearly (90%), speak clearly (83.5%), sleep well (91.3%), accomplish daily activities (90.0%), interact with others (87.8%), and live your personal life (88.7%).<sup>56</sup>

In comparison to these findings the present study also found high incidences of feeling tired, nasal symptoms (runny nose) and coughing. When comparing functional / impairment symptoms Barrett reported percentages in the 83-95% range where the present study reported percentages in the 7-57% range. These relatively low percentages may be a result of our population's unique training and exercise demands.

In the current study the average length of URTIs was  $5 \pm 3$  days with a range of 0-11 days. The results also show that those in the INT group experienced longer URTIs ( $6 \pm 3$  days) than those in the CON group ( $3 \pm 1$  days). Subjects who experienced URTIs did not differ in average race times, or age as a result no single factor was found to influence length in URTIs.

#### *Upper Respiratory Tract Infections and Hours Trained*

The current study found no significant 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 the overall severity and overall symptom scores of those who did get SYM ( $r=0.511$ ,  $p=0.002$  and  $r=0.452$ ,  $p=0.008$  respectively). In a study by Toillier et al the incidence and severity of URTI symptoms were observed during 3-weeks of military training followed by a 5-day combat course.<sup>27</sup> Over 65% of

subjects experienced at least one URTI. Toillier found an increased incidence of URTIs over the duration of study with the most URTIs occurring 11 days into training. Toillier suggested that the large volume of training could have resulted in the increased incidences of URTIs.

Looking at more endurance type athletes, Allgrove performed a study that observed the incidence of URTIs in elite swimmers during a 6-month period of training and competition.<sup>23</sup> The highest incidence of URTIs was immediately after a competition, which was preceded by several weeks of intense training<sup>23</sup> Similar to Toillier, Allgrove suggests that the increased volume of training leading up to the competition may have resulted in the increase in URTIs report post competition.

These findings by Toillier and Allgrove coincide with the positive correlation found between hours trained and overall symptom and severity scores in the current study. All three studies suggest that large volumes of training can potentially increase the incidence of URTIs.

It should noted that the average severity scores of all URTIs reported in the current study, were classified as either very mild or mild and had little interference with the subject's ability to function normally. As a result, training volume cannot be considered a definite predictor of URTIs, but should be explored in greater depth in future research.

#### *Energy Expenditure and Energy Intake: Intervention and Control Groups*

In the present study the INT group consumed a significantly larger amount of CHO during the race, where the amount of fat consumed by the CON group post race was significantly larger than the INT group. Despite the nutritional supplementation there were no significant differences in CHO consumption post race or overall caloric intake

for race day. The American College of Sports Medicine (ACSM) recommends 3.0-4.5 g/kg/day of CHO for endurance athletes.<sup>57</sup> On race day the amount of CHO consumed by the INT and CON groups were  $3.88 \pm 1.72$  g/kg and  $3.85 \pm 2.39$  g/kg respectively. Both groups fell within the ACSM CHO guidelines for endurance athletes, which may explain why there were no observed differences in the number or severity of URTIs experienced between the INT and CON groups

The average post race PRO consumption of the INT group was significantly greater than the CON group ( $111.40 \pm 18.30$  and  $74.06 \pm 47.62$  respectively) indicating that the nutritional supplementation likely influenced post race PRO consumption. In efforts to recover from the increased PRO oxidation that occurs during endurance exercises, based on the findings of Burke et al,<sup>58</sup> the Academy of Nutrition and Dietetics recommends increased PRO uptake post intense endurance exercise. Burke recommends in order maintain nitrogen balance ultra-endurance athletes should consume 1.2-1.4 g/kg/day of protein.<sup>58</sup> Burke's recommendations have been adopted by ACSM and can be found in the ACSM Nutrition Position Statement.<sup>57</sup> The PRO consumption on race day for both the INT and CON groups went beyond Burke's recommendations (INT:  $2.1 \pm 0.6$ ; CON:  $1.8 \pm 0.7$ ). Similar to the CHO consumption, there was more than adequate amount of PRO consumption by both groups. This result may explain the lack of significant differences in incidence and severity of URTIs between the INT and CON groups. Though there were differences in PRO consumption both groups had sufficient amounts of PRO, therefore both groups may have experienced the benefits of PRO consumption during recovery.

Though both group averages met the ACSM's recommendations for CHO and PRO, there is no current literature to state that these specific recommendations reduce the incidence and severity of URTIs. All but two subjects met these recommendations but thirteen subjects reported URTIs. Therefore it can be concluded that meeting these recommendations protects against URTs. Instead these recommendations were used to show that the INT and CON groups had similar energy intakes, which could explain the similar incidence and severity in URTIs between groups.

There were no significant differences in the average caloric expenditure and average caloric intake during and post race between the INT and CON groups. However, subjects were at a nutrient deficit during and post race, with an average nutrient deficit during the race of  $7,741 \pm 1620$ kcal and  $3027 \pm 2702$ kcal post race. According to Venkatraman et al nutrient deficits may suppress the immune function and increase the risk of experiencing an URTI.<sup>59</sup> The lack of significant differences in nutrient deficits could have contributed to the similar incidence and severity of URTIs between the INT and CON groups.

When groups were examined based on health following the race, the SYM group consumed less kilocalories the day before the race, and post race. Subjects that experienced URTIs also consumed less CHO the day before the race, fats during the race, and CHO and fats post race. Though most of the literature looks at the influence of CHO on the immune system, there is little research looking at the effects of fat intake. Due to the length of time these athletes are competing (11.4 hours), many athletes would have needed to use fat as an additional source of fuel to continue racing. The fact

that the nutritional supplementation only consisted of 1g of fat per serving may also explain why there were no differences in the INT and CON groups.

Based on the findings of the current study, further research is needed to truly explore the influence of energy expenditure and energy intake on the incidence and severity of URTIs, specifically the roles of fat intake post ultra endurance events.

#### *Salivary Immunoglobulin A (SIgA) Concentrations and Upper Respiratory Tract Infections*

Current research suggests that there is an inverse relationship between SIgA concentrations and experiencing of URTI symptoms.<sup>3</sup> AMPOST SIgA concentrations were significantly and positively with CHO consumed on race day and positively but not significantly correlated with CHO consumed post race. This indicated that AMPOST concentration may be positively influenced by CHO consumption. By increasing the SIgA concentration it is believed to reduce the incidence of URTIs.

Costa et al performed a similar study looking at the influence of a CHO-PRO solution on SIgA concentrations post exercise.<sup>60</sup> Costa et al found SIgA concentrations decreased after exercise but the CHO-PRO solution did not have any effect on SIgA concentration.<sup>60</sup> Nieman et al performed a study looking at the change in SIgA concentrations following a marathon after ingesting 650mL of a CHO solution (6% CHO, Gatorade) or 650mL of a placebo solution.<sup>61</sup> Similar to previous findings Nieman et al found that the average SIgA concentrations decreased following the marathon, but the change in concentration was not affected by CHO ingestion.<sup>61</sup>

Like the previous studies mentioned above and others mentioned in the literature review, the present study found a decrease in SIgA concentration after prolonged exercise.<sup>20,25,27,60,61</sup>

In regards to CHO-PRO consumption the current study's findings did not coincide with the previous findings of Costa et al and Nieman et al. In the present study the correlations between AMPOST SIgA concentration and CHO consumption indicated that AMPOST SIgA concentrations increased with CHO consumption. This phenomenon was also found in Allgrove's study looking at elite swimmers. Allgrove found that ingestion CHO during prolonged exercise increased SIgA when compared to fasting during exercise.<sup>27</sup> Based on the findings of these studies the relationship between the incidence and severity of URTIs and SIgA concentrations remains to be unclear and inconsistent.

The BASE SIgA concentration was significantly greater in those subjects who experienced URTIs. Though there were no significant differences in AMPOST and changes in SIgA concentrations, average concentrations decreased after exercise in both groups. The elevated SIgA concentrations in the SYM population at BASE contradicts previous literature and the inverse relationship between SIgA and the incidence of URTIs. 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. As a result it seems that SIgA concentrations vary at a individual level and could have skewed the results of the present study. To date there are no specific ranges of concentrations to define if an individual is symptomatic. Rather the literature states that a decrease in SIgA concentrations is predictive of URTIs



### *Salivary Immunoglobulin A (SIgA) Concentrations and Hours Trained*

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 found that post exercise SIgA concentrations in elite swimmers decreased over a 7-month training period.<sup>20</sup> Similar to Gleeson, Allgrove et al found SIgA concentrations to decrease after exercise in elite swimmers over a 6-month period of training and competition.<sup>23</sup> One theory behind the current study's findings may be that those who train more are more experienced and therefore their body has developed an adaptation to their training style. There is currently no literature to support this theory and therefore the relationship between SIgA concentrations and hours trained remains undefined.

### **Limitations**

As previously mentioned the current study was a field study, taking place at the 2013 Lake Placid Ironman Triathlon. Due to the nature of the present study several limitations occurred during data collection that may have impacted the findings of the present study. The weather on race day was mild with a high of 71.0°F (21.7°C) and low of 60.0°F (15.6°C), partly cloudy to overcast conditions with periodic rain showers. As a result subjects were not exposed to thermal strains during the race, and may have experienced less physiological stresses than they normally would have experienced. The level of physiological stress could have potentially reduced the plasma concentrations of stress hormones (such as cortisol) post race. According to findings by Venkatraman et al elevated stress hormones such as cortisol may suppress the

immune system increasing the incidence and severity of URTIs.<sup>19</sup> In accordance to Venkatreman's findings the potential decrease in physiological stresses could have contributed to the present study's low incidence rate of URTIs.

The research team did not restrict the diets of subjects outside data collection time points. As a result many Ironman tri-athletes are well aware of the importance of replenishing their energy stores during and post race. As a result this study found that both groups ate similar diets despite the nutritional supplementation. The lack in variance between groups could be a result of having a well-educated group of subjects. The lack of variance may be a limitation in analyzing data, but could be a strong observational tool for future research.

Due to the various locations of our subjects all URTI symptoms 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.<sup>20,22,23,25</sup>

In terms of budgeting, the current study was had several financial constraints. As a result the research team was only able to use one immune indice (SIgA), where previous literature has used multiple indices such as lymphocyte subsets, leukocyte concentrations, and NK cell activity. Though saliva samples were collected at all five times points due to the financial constraints of the present study only BASE and AMPOST concentrations were analyzed.

Sample size and variety can also be considered as a limitation to this study. The present only had four females participants, whom all reported experiencing a URTI post

race. Due to the small number of female subjects, and not having any ASYM females to compare to it can not be concluded that gender influences the incidence of URTIs.

Limitations also occurred during post-hoc analysis in regards to the estimation of energy expenditure. To date there is no current literature or equations that calculate the energy expended while competing in an Ironman Triathlon. As a result the research team used multiple equations from multiple sources to estimate energy expended. In calculating the energy expended during the swim and bike portions of the race, METs was used. The use of METs is a validated and reliable, but a particular amount of METs is provided for a range of speeds and therefore not highly specific. For example in Heyward's Advanced Fitness Assessment and Exercise Prescription bicycling at 12-19 mph is 12 METs. As a result a subject who averaged a 12 mph pace and a subject who averaged a 19 mph were given an equal amount of METs, which may not account for all kilocalories expended.

Lastly it is important to note that this study only focused on a small group in a large population of endurance athletes. The Ironman Triathlon is extremely different from many other kinds of exercise and these results are strictly applicable to ultra-endurance Ironman triathletes.

## **Future Research**

Based on this study's findings, the use of a nutritional supplementation on the incidence and severity of URTIs after an Ironman triathlon still remains greatly undiscovered. Looking at the macronutrient consumption the SYM group consumed

significantly less fat. Current literature suggests that CHO consumption post race is beneficial. In regards to fat intake, most literature to dates focuses on pre race fat consumption where little is known about fat consumption, or fat intake recommendations post ultra endurance events. As a result future research should look at the role of fat intake on the incidence in URTIs, specifically after ultra endurance events.

Due to the positive correlations between overall URTI symptom scores and overall URTI severity scores with hours trained further research should observe Ironman triathletes throughout a season of training and competition. A well-controlled longitudinal study tracking URTI symptoms throughout training session and in between competitions using multiple immune indices would contribute to the current literature and could answer some of the questions that remain inconclusive such as determining the predictors or predisposing factors that increase the incidence of URTIs in ultra endurance athletes.

Future study designs should also consider laboratory studies, which would allow for better control over variables such as environment, exercise intensity/duration, as well as energy intake.

## **Practical Applications**

Though all subjects in the present study met the ACSM recommendations<sup>57</sup> for CHO and PRO intake, those who experienced URTIs on average consumed less energy throughout the study. In particular those in the SYM group consumed less CHO and fat, which are consisted two of the main sources of fuel while performing endurance

exercise. The current literature believes that nutrient deficits increase the risk of experiencing URTIs.<sup>59</sup> To ensure athletes are meeting dietary recommendations, and are replenishing depleted energy stores athletes should record all energy consumption during and post exercise. This should be can be established while training and once mastered may help enhance performance during competition.

Predisposing factors have yet to be established, therefore these practical applications should only be used as recommendations. Based on the results of the current study, there are no definite solutions to reduce the incidence or severity of URTIs.

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