Body Composition, Dietary Intake and Supplement use among Triathletes residing in the Western Cape Region

by:

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Declaration

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Date

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ABSTRACT

Objective: The aim of this study was to determine the body composition, dietary intake and supplement use among training olympic and ironman distance triathletes residing in the Western Cape region.

Design: Descriptive, analytical, cross-sectional study design

Setting: Western Cape Province (South Africa)

Subjects: Triathletes residing in the Western Cape region registered with Triathlon South Africa (N = 26)

Outcome measures: Percentage body fat, total energy intake, macro– and micronutrient intake, use and reasons for use of nutritional supplements or nutritional ergogenic aids.

Results: The mean age of the men and women was 37.9 [Standard Deviation (SD) 6.82] and 37.5 (9.6) years respectively. The corresponding mean amount of training per week for men and women respectively were 15.1 (4.1) and 15.3 (4.7) hours. The percentage body fat as determined by multi-frequency bio-electrical impedance analysis of the men and women were 12.97% (4.3) and 21.4% (6.3) respectively. The mean dietary macronutrient intake as determined by a three day food record for men was for total energy intake 14 534.7kJ (4509.8), carbohydrate intake 5.3g/kg body weight (BW) (1.9), protein intake 2.0g/kg BW (0.5) and fat intake 34.6% (10.31) of total energy requirements. Dietary micronutrients not reaching 67% of dietary reference intakes (DRI) from food alone included iodine (44%) and fluoride (49%). Vitamin C (154%). Micronutrient intake above upper limit (UL) was sodium (213%), manganese (162%) and niacin (228%). The dietary macronutrient intake for women was for total energy intake

9004.1kJ (2368.8), carbohydrate intake 3.5g/kg BW (1.0), protein intake 1.2g/kg BW (0.2) and fat intake 29.8% of total energy intake (6.0). Micronutrients not reaching 67% of the DRI were chloride (61%), iodine (31%) and fluoride (52%). Micronutrient intake above the UL was vitamin C (218%) and manganese (174%). The dietary intake of the men was inadequate in carbohydrate, provided sufficient energy and protein and excessive fat. The dietary intake of the women was inadequate in total energy and carbohydrate, with an adequate protein intake and excessive fat intake. Although the sample size was very small, some associations were found between dietary intake and clinical health status. Seventy three percent of the triathletes use over the counter dietary supplements. The supplements used most often included carbohydrate supplements (81%), multivitamin and mineral supplements (81%) single vitamins (65%), protein supplements (100%), single minerals (58%), antioxidants (54%) and herbal supplements (42%). Most popular reasons for consuming supplements included recovery (62%), increasing energy supply (61%), enhancing immune function (50%), exercise performance enhancement (46%), increasing muscle mass (54%) and to make up for an inadequate diet or nutrient replacement (31%).

Conclusion: Percentage body fat of the men and women were at the upper end of the range associated with elite athletes. The athletes have a fairly good intake of macro– and micro-nutrients. Inadequate habitual carbohydrate intake can be attenuated by the vast majority of the triathletes taking additional carbohydrate supplementation. Supplements were used widely among the athletes, whether it is scientifically proven to be beneficial or not.

Opsomming

Doel: Die doel van die studie was om die liggaamsamestelling, dieet inname en supplement gebruik van olimpiese en ysterman afstand driekamp atlete in die Wes-Kaap provinsie te bepaal.

Studie ontwerp: Beskrywende, analitiese, deursnit studie ontwerp

Omgewing: Wes-Kaap provinsie (Suid-Afrika)

Studie populasie: Driekamp atlete wat in die Wes-Kaap omgewing woon en geregistreer is by die vereninging vir driekamp atlete in Suid Afrika (TSA) (*N* = 26)

Uitkomste: Persentasie liggaamsvet, totale energie inname, makro –en mikronutriënt inname, gebruik en redes vir die gebruik van supplemente of ergogeniese middel.

Resultate: Die gemiddelde ouderdom van die mans was 37.9 (6.8) jaar en die vroue 37.5 (9.6) jaar. Die gemiddelde hoeveelheid oefening per week vir mans en vroue onderskeidelik was 15.1 (4.1) en 15.3 (4.7) ure. Die persentasie liggaamsvet was 12.97% (4.3) en 21.4% (6.3) vir mans en vroue onderskeidelik gemeet deur multi-frekwensie bio-elektriese impedansie. Die dieet makronutriënt bepaal deur ’n drie dag voedsel rekord inname vir mans was vir totale energie inname 14 534.7kJ (4509.8), koolhidraat inname 5.3g/kg liggaams gewig (LG) (2.0), proteïen inname 2.0g/kg LG (0.5) en vet inname 34.6% van totale energie (10.3). Mikronutriënte wat nie 67% van die daaglikse aanbevole inname (DRI) bereik nie, sluit in jodium (44%) en fluoried (49%).. Mikronutriënt inname bo die boonste vlak van die (UL) was vitamien C (154%), natrium (213%), mangaan (162%) en niasien (228%). Die makronutriënt inname vir vroue was vir totale energie inname 9004.1kJ (2368.8), koolhidraat inname 3.5g/kg LG (1.0), proteïen inname

1.2g/kg LG (0.2) en vet inname 29.8% van totale energie (6.0). Mikronutriënte wat nie 67% van die DRI bereik het nie, was chloried (61%), jodium (31%) en fluoried. Mikronutriënt inname bo die UL was vitamien C (218%) en mangaan (174%). Drie en sewentig persent van die driekamp atlete gebruik oor die toonbank dieet supplemente. Supplemente wat die mees gereeldste gebruik was: koolhidraat supplemente (82%), multi vitamien en mineraal supplemente (81%), enkele vitamiene (65%), proteïen supplemente (100%), enkele minerale (58%), anti-oksidante, (54%) en kruie supplemente (42%). Die mees algemeenste redes vir supplementasie was herstel (62%), verhoogde energie voorsiening (61%), bevordering van immuun funksie (50%), oefening prestasie bevordering, (46%), verhoogde spiermassa (54%) en om te kompenseer vir moontlike onvoldoende dieetinname om nutriënte te vervang (31%). Die dieet inname van die mans het nie genoeg totale energie en koolhidrate verskaf nie, maar was toereikend in proteïen en het selfs te veel vet verskaf. Die dieet inname van die vroue was onvoldoende in totale energie en koolhidrate, die proteïene was genoegsaam en die vet inname te hoog. Alhoewel die studie populasie baie klein is, was daar sommige positiewe korrelasies met dieet inname in kliniese gesondheid status.

Gevolgtrekking: Die persentasie liggaamsvet van die mans en die vroue was op die hoër grens van die aanvaarbare persentasie liggaamsvet vir driekamp atlete. Die atlete het ’n goeie makro –en mikronutriënt inname. Die onvoldoende gewoontelike koolhidraat inname van die atlete kan moontlik ’n rede wees hoekom die meerderheid van hulle aangedui het dat hulle ekstra koolhidraat supplemente neem. Supplemente word algemeen gebruik deur die atlete, of daar wetenskaplike bewyse daarvoor is al dan nie.

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List of Abbreviations

%BF:	Percentage body fat
ATP:	Adenosine triphosphate
AI:	Adequate intake
ANOVA:	Analyses of variance
AIS:	Australian institute of sport
BMI:	Body mass index
BMR:	Basal metabolic rate
BW:	Body weight
CI:	Confidence interval
CHO:	Carbohydrate
DEXA:	Duel-x-ray absorbtiometry
DRIs:	Dietary reference intakes
EAR:	Estimated average requirement
GI:	Glycemic index
GL:	Glycemic load
g/kg:	gram per kilogram
HMB:	β-hydroxy-β-methyl-butyrate
LG:	Liggaamsgewig
MF-BIA:	Multi-frequency Bio-electrical Impedance Analysis
MSM:	Multi-sport magazine

NAA:	Neutron activation analysis
RDA:	Recommended daily allowance
SD:	Standard deviation
SF-BIA:	Single-frequency Bio-electrical Impedance Analysis
SKF:	Skinfold measurement
SSISA:	Sport Science Institute of South Africa
TBK:	Total body potassium
TE:	Total energy
TBW:	Total body water
TSA:	Triathlon South Africa
UL:	Tolerable upper intake level
URTI:	Upper respiratory tract infection
UWW:	Under water weighing
WHO:	World Health Organization
WPTA:	Western Province Triathlon Association

Explanation of Terms:

Antioxidant:	A molecule that slows a free radical chain reaction propagating the oxidation of lipids. The critical use of the antioxidant term should include molecules that are protected from oxidation, and the resulting damage that is prevented.[3]
β-oxidation:	Process in which fatty acids are broken down by the sequential removal of 2 carbon units.[7]
Carbohydrate loading:	Carbohydrate loading is a strategy involving changes to training and nutrition that can increase muscle glycogen (carbohydrate) stores prior to endurance competition.[23]
Dietary supplement:	A product, other than tobacco, which is used in conjunction with a healthy diet and contains one or more of the following dietary ingredients: a vitamin, mineral, herb or other botanical, an amino acid, a dietary substance for use by man to supplement the diet by increasing the total daily intake, or a concentrate, metabolite, constituent, extract, or combinations of these ingredients.[41]
Duathlon:	Involves 2 sporting disciplines, cycling and running, one following directly after the other. The olympic distance duathlon consists of a 10km run, 40km cycle and a 5km run.[2]

Endurance training: Endurance training is defined as exercise training to increase an individual's duration tolerance for aerobic exercise.[1]

Energy balance: Optimal energy intake during times of high intensity exercise as enough energy consumed to sustain body weight, optimize training and exercise performance and to generate good health.[12]

Exercise: Any muscular activity that generates force and disrupts homeostasis.[1]

Female Athlete Triad: Abnormal eating patterns associated with menstrual dysfunction and a subsequent decrease in bone mineral density or osteoporosis. The 3 conditions i.e. disordered eating, amenorrhea and osteoporoses occur together in female athletes.[153]

Glycemic index: Blood glucose indicator. It provides us an indication of the rate at which the food affects blood glucose levels, after it has been eaten. The GI rating of a food is compared to a reference food, usually glucose.[19]

Glycemic load: Expression of how big a glucose load the body has to deal with, to keep blood glucose levels within normal ranges. It is calculated by taking the percentage of the food's carbohydrate content per portion and multiplying it by its glycemic value.[19]

Glycogenesis:	The synthesis of glycogen from glucose.[7]
Glycogenolysis:	The breakdown of glycogen.[7]
Glycolysis:	Metabolic pathway that converts glucose to pyruvate (aerobic) or lactic acid (anaerobic).[7]
Hypoglycemia:	Low plasma glucose concentrations.[3]
Ironman triathlon:	Involves 3 sporting disciplines, swimming, cycling and running, one following directly after the other. The Ironman distance triathlon consists of a 3.8 km swim, 180 km cycle and a 42.2 km run.[2]
Lipolysis:	Lipid breakdown.[7]
Nutritional ergogenic aids:	Any means of increasing muscle mass, delaying fatigue and enhancing energy utilization, including energy production, control, and efficiency. Athletes frequently use ergogenic aids to improve their performance and increase their chances of winning in competitions.[41]
Olympic triathlon:	Involves 3 sporting disciplines, swimming, cycling and running, one following directly after the other. The Olympic distance triathlon consists of a 1.5 km swim, 40 km bicycle and a 10 km run.[2]
Reactive oxygen species:	A substance that prevents damage caused by free radicals. Free radicals are highly reactive chemicals that often contain oxygen. They are produced when molecules are

split to give products that have unpaired electrons. This process is called oxidation.[3]

VO_2 maximum: The measure of maximal oxygen uptake and it determines the persons' ability to take in, transport and use oxygen[1]

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION AND STATEMENT OF THE RESEARCH QUESTION

1.1 Introduction

In today's fast pace and modern society, human beings are increasingly concerned about health, nutrition and fitness. More and more people all over the world are taking up new sports or physical fitness activities. For some people, exercise is a way of living, a way of defining who they are; these extraordinary athletes form part of a new global trend leading to participation in events like triathlon or even for some, the ultimate test of endurance, an ironman event.

Endurance training is defined as exercise training to increase an individual's duration tolerance for aerobic exercise.[1] Endurance events can often be 90 minutes like a sprint triathlon event, 17 hours like an ironman event or longer and therefore termed one of the greatest tests of endurance, albeit physically, psychologically or emotionally. Two types of endurance events and subjects will be focused upon, namely triathletes training for olympic distance triathlon (1.5 km swim, 40 km bike, 10 km run) and triathletes training for ironman distance triathlon (3.8 km swim, 180 km bike and 42.2 km run).[2]

A healthy eating pattern and physical exercise are well documented as being inseparable. Nutrition is known to play a key role in exercise performance and endurance during extensive periods of exercise. It is the single most important complimentary factor to any sport or exercise "fanatic."[3]

1.2 Exercise Metabolism

Energy for performing endurance triathlons comes from carbohydrate, fat and protein intake, which act as substrates that fuel chemical reactions, catalyzed by co-factors and enzymes to produce adenosine triphosphate or better known as ATP.[1,4,5] A continuous supply of ATP is needed for exercising muscle.[6] ATP can be synthesized via various pathways, depending on the intensity and duration of exercise as illustrated (figure 1.1).[6] Intracellular stores of ATP and creatine phosphate can provide power for maximal bouts of exercise that lasts for a few seconds (1-2 seconds). Anaerobic glycolytic pathways are oxygen independent and can sustain energy for up to 1 minute during high intensity exercise.[1,4,5] During anaerobic glycolysis, the muscle breaks down glycogen without consuming oxygen. Aerobic glycolytic and aerobic lipolytic systems are oxygen-dependent and sustain all exercise lasting longer than 1 minute whilst utilizing carbohydrate and fat to generate energy.[1,4,5]

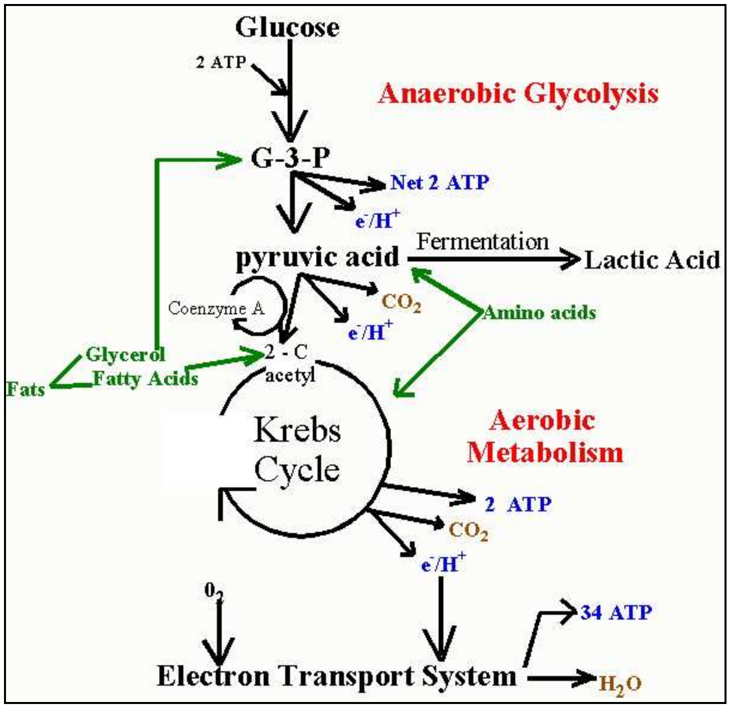

Figure 1.1 Diagram illustrating anaerobic glycolysis and aerobic metabolism
Source: Swan, J. 2005[6]

Endurance capability in this sense is often measured via VO_2 Max.[4] This is the measure of maximal oxygen uptake and it determines the persons' ability to take in, transport and use oxygen.[1] In other words, aerobic power indicates the ability of an individual to perform sustained, high intensity exercise.[4] When the relative intensity is less than 30% of VO_2 max, e.g. during a leisurely walk, it is mainly fat stores being utilized for energy in the fasted state.[4] When jogging or brisk walking, the relative intensity ranges from 40-60% of VO_2 max and fat and carbohydrate are utilized evenly.[4] During running or hard running when the relative intensity exceeds 75-80% of VO_2 max, mainly carbohydrate is used for fueling working muscles.[4]

Exercise is defined by the American College of Sports Medicine as "any muscular activity that generates force and disrupts homeostasis", it is a normal physiological state, not pathological and in general is affected by illness or inflammation due to injury or insult.[7,8]

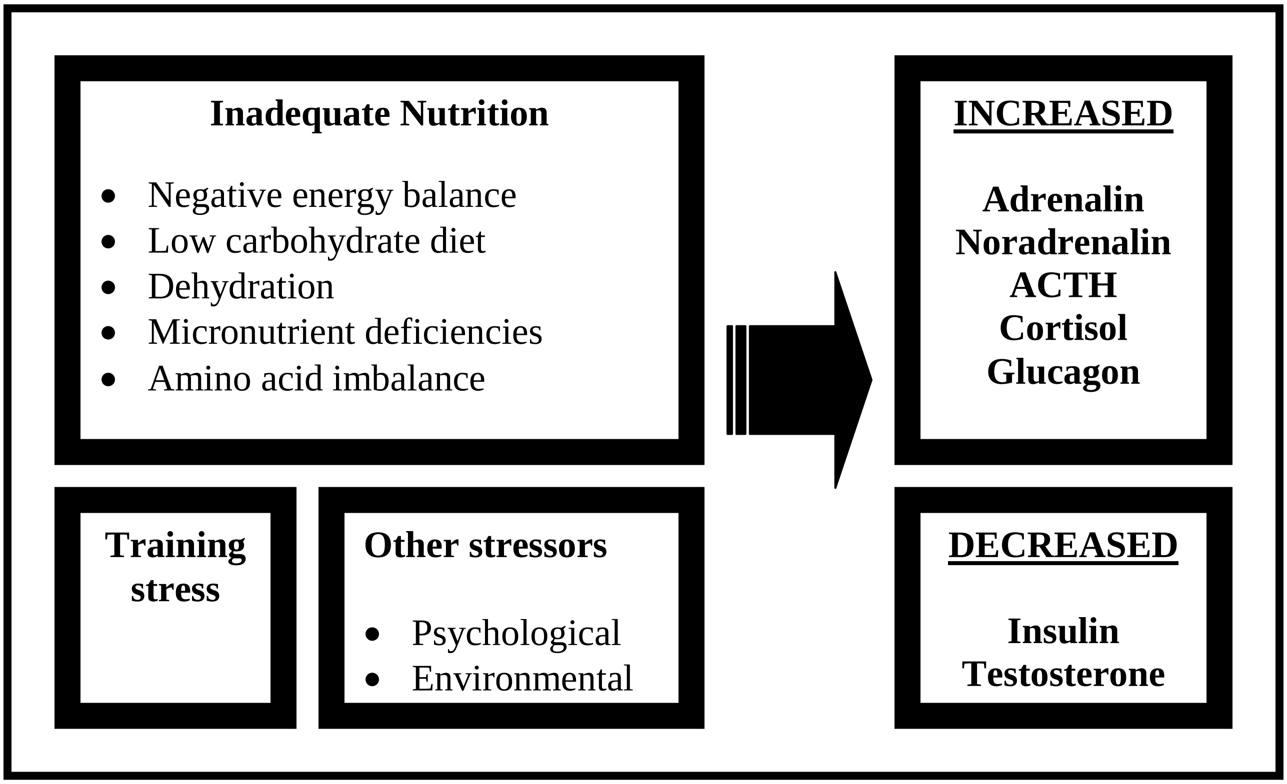

Figure 1.2 Nutrition and the stress hormone response
Source: Adapted from Gleeson et al. 2000[9]

The body however can adapt to the metabolic response to exercise through endurance training.[10] When the physical fitness of an athlete increases or the nutritional status is optimized, the respiratory exchange ratio decreases and there is an increased rise in plasma free fatty acids.[10] The body's ability to oxidize lipids and reduce the rate of blood glucose utilization from muscle increases.[10] There is also an increased utilization of intramuscular triglycerides as an energy source.[10] In other words, with nutritional intervention and conditioning, the human body can optimize carbohydrate and fat metabolism to sustain exercise for prolonged periods of time.

1.3 Dietary Intake

In all sport, the main goal of nutritional strategies is to target and eliminate the factors that lead to fatigue and impair performance; factors affecting the latter include hyperthermia, hypoglycemia, dehydration, muscle glycogen depletion, gastro-intestinal disturbances and electrolyte imbalances.[11]

Athletes can only sustain an elite level of performance when they manage to maintain energy balance.[12] European, World and Olympic medal winner male triathletes had a reported mean energy intake of 272kJ/kg/day as reported via a 4-7day food diary.[13] Another reported energy intake of male triathletes was 19.1MJ/day (4584kCal/day).[11] Women endurance runners have a reported mean energy intake of 5860-8330kJ, which is well below the men's intake and the recommendations for women.[14] The American Dietetic Association describes optimal energy intake during times of high intensity exercise as enough energy consumed to sustain body weight, optimize training and exercise performance and to generate good health.[12]

Good nutrition assists in training hard; muscle recovery and metabolic adaptations to endurance exercise.[15] Adequate energy should come from a wide variety of available foods which provide carbohydrate, protein, fat and micronutrients.[15] Energy, macro– and micro-nutrient intake has the ability to optimize body weight and composition and enhance performance.[15]

1.4 Role of Macronutrients in Sport and Performance

1.4.1 Carbohydrate

The field of sport nutrition has moved away from calculating energy requirements as a percentage of the total energy requirement and is rather focusing on determining requirements expressed as grams per kilogram body weight.[16] Requirements are given in g/kg body weight and when the macronutrient intake is sufficient, total energy requirements will be met.[16,17] The g/kg body weight requirement ensures that adequate macronutrients are provided in respect to total energy intake and that there is some flexibility when it comes to individualizing nutrition plans according to specific training regimes.[17]

1.4.1.1 Daily carbohydrate requirements

A nutritional ergogenic aid is defined as "a substance or practice that increases energy or work output" i.e. prevents and/or postpones fatigue.[3] The suggested carbohydrate intake to have an ergogenic effect and to reduce this negative effect is 60-70% of total energy intake. Muscle glycogen and blood glucose are the primary sources of energy for contracting muscles.[18] An optimal dietary carbohydrate intake enhances recovery and optimizes glycogen stores for the next training session. The habitual dietary requirement for carbohydrate differs according to the amount and intensity of training. (Table 1.1).[16]

The glycemic index is defined as a blood glucose indicator. It provides an indication of the rate at which food affects blood glucose levels after it has been eaten.[19] The glycemic load is an expression of how big a glucose load the body has to deal with to keep the blood glucose values within the normal ranges.[19] There are currently no clear recommendations and data on the efficacy of GI and GI load on sport performance, although the glycemic index of CHO may also be a useful tool in endurance training, its role needs to be better defined since there is currently insufficient evidence that all athletes will benefit form eating a low GI meal before exercising.[20,21] In fact, it is known that the effect of a pre-event low GI meal is diminished when carbohydrate is ingested during a race.[20,21] The most important aspects of CHO intake currently thought to be important is reaching daily carbohydrate requirements and gastro-intestinal comfort, since attaining the high carbohydrate intake that is required for intensive exercise can lead to abdominal bloating, cramping and diarrhea.[20,21]

Table 1.1 Recommended daily carbohydrate requirements for athletes

Frequency and Intensity of activity	Carbohydrate requirement (g/kg/day)
General sports activity < 60 minutes, or unlimited low intensity > 4 X per week, normal weight	5-6g/kg/day
60-120 minute intense or lengthy (g/kg/day) Moderate intensity exercise > 4X per week	6-8g/kg/day
Endurance training > 120 minutes (g/kg/day) Intense daily exercise	8-10g/kg/day
Extreme exercise: 5-6 hours intense daily exercise (g/kg/day)	10-12g/kg/day

Source: Hawley 1998[16]

1.4.1.2 Carbohydrate before exercise

Carbohydrate loading is a strategy involving changes to training and nutrition that can maximize muscle glycogen stores prior to endurance exercise.[22,23] Literature suggests that carbohydrate loading can increase performance by 2-3% over a specified distance.[22,23] An increased carbohydrate intake to 7-10 g/kg/d (Table 1.2) for 1-4 days prior to the race, whilst tapering, i.e. reducing exercise frequency, and duration is known as carbohydrate loading.[22,23] This elevates muscle glycogen stores and is said to increase endurance and performance in events lasting longer than 90 minutes.[22,23] The CHO loading regime is complemented by consuming sufficient CHO before, during and after the endurance event. The pre-event meal should contain 1-4g/kg body weight carbohydrate and should be eaten 1-4 hours before the event (Table 1.2).[22,23]

1.4.1.3 Carbohydrate during exercise

Common complaints during endurance events include muscle fatigue and hypoglycemia, often as result of low muscle glycogen stores or less than optimal hydration status.[24] An increase in liver and muscle glycogen stores and optimal fluid intake, is therefore needed for peak performance.[24] Symptoms of sub-optimal carbohydrate intake, include lack of energy, heavy legs, fatigue or “hitting the wall”, slow rate of recovery, loss of concentration, dizziness, irritability and fainting.[25,26] and ingestion of carbohydrate is recommended at 1g per minute or 60 g/hour during an endurance event.(Table 1.2)[26,27,28]

1.4.1.4 Carbohydrate after exercise

Carbohydrate intake is mainly responsible for increasing glycogen stores and the available evidence indicates that ideal levels of carbohydrate supplementation optimizes muscle glycogen synthesis.[26,28]

Recovery with carbohydrate is suggested at 1 g/kg body weight in the first 30 minutes after exercise and every 1-2 hours until normal meal patterns are resumed.[26,28] (Table 1.2)

Table 1.2 Carbohydrate strategies before, during and after an event.

Situation	Recommended Carbohydrate Intake
Daily refuelling needs for training programs less than 60-90 min per day or low intensity exercise	Daily intake of 5-7 g per kg BM
Daily refuelling for training programs greater than 90-120 min per day	Daily intake of 7-10 g per kg BM
Daily refuelling for athletes undertaking extreme exercise program - 6-8 hours per day (cycling tour)	Daily intake of 10-12+ g per kg BM
Carbohydrate loading for endurance and ultra-endurance events	Daily intake of 7-10 g per kg BM
Pre-event meal	Meal eaten 1-4 hours pre-competition 1-4 g per kg BM
Carbohydrate intake during training sessions and competition events greater than 1 hour	1 g per min or 60 g per hour
Rapid recovery after training session or multi-day competition, especially when there is less than 8 h until next session	Intake of 1 g per kg BM in the first 30 min after exercise, repeated every 1-2 hours until regular meal patterns are resumed

Source: Australian Institute of Sport 2004[28]

1.4.1.5 Carbohydrate and the immune function

It has been said that prolonged exercise and heavy training are associated with reduced immune cell function.[29] Current evidence shows that athletes are at an increased risk of especially upper respiratory tract infections (URTI) during periods of heavy training as well as up to two weeks post-race day.[30] A study done by Nieman et al. 2006[30] reported that 25% of runners reported URTI during the 2 week period following a 160km race.[30]

Exercise immunology studies indicate that positive immune changes leading to fewer days of sickness with the common cold and decreased prevalence of URTI take place during moderate physical activity (30 minutes, 3 times per week).[31] The risk of URTI increases when individuals train excessively for prolonged periods. There are other factors that increase this risk including exposure to pathogens during travel, lack of sleep, severe mental stress, malnutrition, or weight loss – all of which occur commonly among these athletes.[31] Many components of the immune system exhibit negative change after prolonged, heavy exertion lasting longer than 90minutes.[31] These immune changes include activating elements of the innate (natural killer and neutrophil activity) and adaptive (T and B cell function) immune system.[32,33] Figure 1.3 indicates the immune function response to extended endurance exercise.[34] Progressive training leads to anabolic stimuli and energy depletion, both of which activate immune reactions within the muscle which can lead to inflammation.[34] The suppression of the immune function and the release of interleukins and tumor necrosis factor, also manifests itself in other symptoms, including URTI, skin infections and muscle damage.[31,32,33]

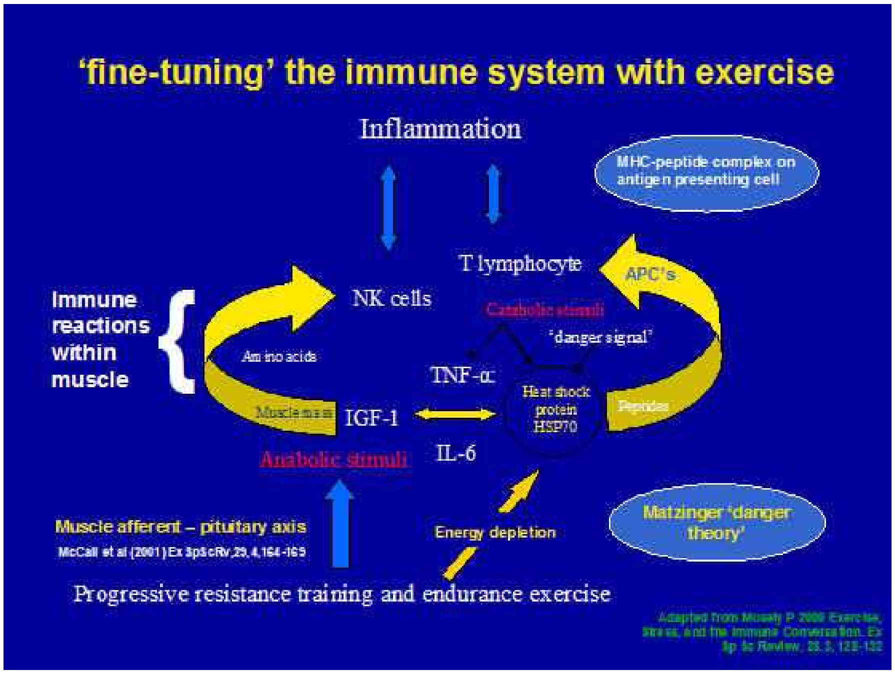

Figure 1.3 Influence of prolonged endurance exercise on the immune system
Source: Martin Krause, 2005[34]

Nieman et al. 2001[35] studied the influence of carbohydrate supplementation, gender and age on pro –and anti-inflammatory plasma cytokine and hormone changes in 98 runners after two marathon races.[35] Plasma levels of IL-10, IL-1 receptor antagonist, IL-6 and IL-8 increased in the runners after the competitive race, irrespective of age or gender. The ingestion of CHO during the race however had a lower rise in cortisol, IL-10 (Figure 1.4) and IL-1 receptor antagonist cytokines.[35]

Although some studies show positive results,[35] no consistent relationship between nutritional interventions, exercise immunology and URTI have been established[35,36]

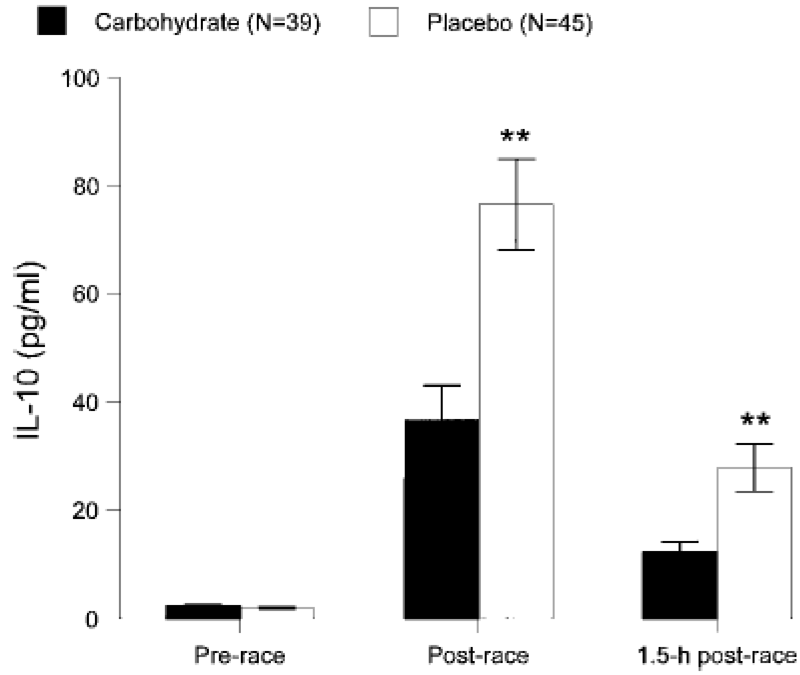

Fig. 2. Pattern of change in plasma interleukin (IL)-10 concentration was significantly different between marathon runners in carbohydrate and placebo groups, with higher levels measured in the placebo group after the race [$F(2,81) = 7.17$, $P = 0.001$]. **Significantly different from prerace ($P < 0.001$).

Figure 1.4 Carbohydrate supplementation attenuates post-exercise rise in IL-10
Source: Nieman, 2001[35]

1.4.2 Fat

The intensity and the duration of exercise determine the contribution of fuel for energy production which , when the duration of exercise is prolonged, energy can be generated from fatty acids.[3,7] is thought that the contribution of fat toward energy during endurance events of longer than 6 hours duration can be 60-70% of the energy requirement.[1,3] The literature also indicates that fat metabolism cannot take place when insufficient carbohydrate is available.[1,3] Elite endurance athletes usually have a few kilograms of body fat, which would be sufficient for several marathon races or triathlons, i.e. they have enough adipose stores to produce energy during ultra-endurance events.[13] With this endogenous fat source, there would be no need to supplement with dietary fat even during an event or training session of long duration.[13]

Fat is stored as triacylglycerol in adipose tissue and intra-muscular triacylglycerol.[37] The limitation with lipid utilization during physical activity is not that it is not available as an energy source but rather it is the transport of the lipids to the site of oxidation in the muscle to be used for the provision of energy.[13] If the transport of these lipids can be affected more efficiently, the limited carbohydrate can be used sparingly and therefore increase endurance and exercise can be prolonged. In a way this can be achieved by physical conditioning.[13] For the time being, the field of sport nutrition can exclude fat loading and high fat diets as an ergogenic tool.[38] The dietary fat requirement for elite endurance athletes according to the American Dietetic Association (ADA) still remains 25% of total energy intake.[12] Carbohydrate is, and still remains, the most important macronutrient in the diet of an endurance athlete, before, during and after an event.[16]

1.4.3 Protein

Dietary protein requirements are elevated with strength, speed or endurance training.[39] Energy intake, exercise intensity and duration, ambient temperature, gender and age also influence protein requirements.[39] The general daily protein requirements for endurance athletes range from 1.2-1.7g/kg body weight.[12,39] Ultra-endurance athletes can have a slightly higher protein requirement, but it should still not exceed 2g/kg body weight.[39] Athletes typically consume 1.2-1.7g/kg body weight protein in habitual intake.[39] Protein supplementation is generally not indicated due to the high habitual protein intake of the athletes.[12] And negative effects of such supplements include fat gain and an increased calcium excretion.[40]

Amino acids, such as glutamine, branched chain amino acids (BCAA), i.e. valine, leucine and isoleucine, lysine, arginine and orthinine, can reduce muscle wasting but little evidence exist to support such claims as arginine, ornithine and lysine increase circulating growth hormone and insulin levels.[41] This increase is small and does not lead to an increase in lean body mass or improved muscle effectiveness.[42]

Matsumoto et al. 2007 found that a single intake of 2g BCAA with arginine supplementation during moderate exercise reduced the catabolic response of exercising muscle.[42] BCAA is also known to be a fuel source for working muscle during prolonged exercise.[43] It has also been reported that 500mg/ kg body weight BCAA supplementation taken during moderate exercise reduced protein degradation due to intense exercise, resulting in reduced muscle damage.[44] More research in this field is however needed.[42]

In contrast to moderate endurance exercise, intense ultra-endurance exercise has an immunosuppressive effect, which affects natural killer cells, lymphokine-activated killer cells and lymphocytes.[45,46] Glutamine is one of the amino acids known to be an important fuel for lymphocytes and leading to stimulation of the immune system.[47] After prolonged exercise, glutamine concentrations drop. Decreased glutamine concentrations have been associated with a higher incidence of infections[48] leading to the widespread interest in supplementing with glutamine to reduce the incidence of infections following endurance exercise.[47,49]

BCAA supplementation can reverse the reduction in serum glutamine concentration after prolonged intense exercise like an olympic distance triathlon due to the fact that BCAA (valine, leucine and isoleucine) acts as precursors for glutamine synthesis.[47]

The role of glutamine in cells of the immune system includes improving mechanisms to respond to injury.[50,51,52,53] Glutamine also has a vital role in immune cell metabolism.[50,51,52,53] After exercise, decreased levels of glutamine can lead to suppressed immune function, while increased plasma glutamine concentrations with regular training can reduce the immunosuppressive effect of physical activity at a high intensity.[50,51,52,53] Low glutamine levels have been associated with overtraining.[50,51,52,54] There is anecdotal evidence supporting the use of glutamine to reduce immunosuppression associated with overtraining, but more research is needed to establish this. It is recommended to rather prevent overtraining syndrome with controlled exercise.[50,51,52,53]

1.5 The Role of Micronutrients in Sport and Performance

Marginal vitamin and mineral deficiencies have been found to be present in elite athletes, due to either reduced absorption by the gastro-intestinal tract, increased excretion in sweat, urine and feces, increased turnover and the consequent biochemical adaptation to physical activity.[54] Athletes take over the counter vitamins and minerals because they believe the supplements to have a beneficial pharmacological effect on their performance.[41] It is believed that the supplements can promote changes due to activity, provide more consistent training sessions, improve recovery of muscle tissue between sessions, reduce the prevalence of injury or infection and enhance their competitive performance.[41]

There is literature supporting possible increased requirements for vitamin C, antioxidants and electrolytes in athletes but other nutrients including iron, calcium, riboflavin, pantothenic acid, niacin, vitamin B12, folate, biotin, multiple B-vitamin supplements, magnesium, zinc, phosphorus, chromium and multivitamin and mineral supplementation did not have any significant effect on performance enhancement in sport, unless a known deficiency is present.[26,41,55,56,57,58,59,60]

Macrominerals like potassium, sulphur, sodium and chloride are also known as the electrolytes. Athletes commonly supplement with these electrolytes due to losses of these nutrients in sweat. Fluid and electrolyte intake is specific for race strategies and is discussed elsewhere.[61,62,63,64,65,66,67]

Broad spectrum multivitamin and mineral supplements can be included when dietary intake is insufficient and should contain no more than 1-1.5 times the recommended daily allowance (RDA) for all vitamins and minerals and can support a low energy intake or a restricted variety diet.[40] However, in the absence of deficiency, supplementation may not have a beneficial effect on either performance or nutritional adequacy. No amount of supplementation will support the lack of proper nutrition.[24,40,41]

1.5.1 Vitamin C and other antioxidants

All effort is made to ensure optimal performance and endurance to be a competitive triathlete. Muscular exercise promotes the production of radicals and other reactive oxygen species in the working muscle.[68,69] Growing evidence indicates that reactive oxygen species are responsible for exercise-induced protein oxidation and contribute to muscle fatigue and reduced immune function.[68,69] Although the role of supplements in endurance sport has been examined and studied, contradictory conclusions have been drawn.[68,69] Furthermore it is general knowledge that inadequate or inappropriate nutrition can aggravate the deterioration in immune function.[29]

Dietary deficiencies of protein and specific micronutrients have been associated with immune dysfunction.[29] An adequate intake of iron, zinc, vitamin A, vitamin E, vitamin B6 and vitamin B12 are only a few of the micronutrients essential for the maintenance of immune function, but excessive intakes or supplementation above the upper limit (UL) has been shown to increase exercise-induced immune depression.[68]

Evidence that supplements including high doses of antioxidant vitamins, glutamine, zinc, probiotics and Echinacea, prevent exercise induced immune impairment is currently lacking.[29] It is however important to remember that enzymes in immune cells require the presence of micronutrients, leading to attempts by investigators to alter changes in immunity following heavy exertion through use of nutritional supplements, primarily zinc, dietary fat, vitamin C, other antioxidants like glutamine and CHO.[70]

Some studies have reported that supplementation with vitamins C and E, other antioxidants, or antioxidant mixtures can reduce symptoms or indicators of oxidative stress as a result of exercise.[71] There are however studies that indicate that supplementation with alpha-tocopherol had no antioxidant effects during endurance exercise and that large doses (800 IU/day of alpha-tocopherol) supplementation for prolonged periods showed pro-oxidant characteristics during endurance exercise.[69,72] Another study showed that vitamin E supplementation of 800 IU/day of alpha-tocopherol compared with placebo ingestion before a competitive triathlon race promoted lipid peroxidation and inflammation during exercise as supposed to having an antioxidant effect.[73]

In a study done on Comrades runners (90km) the authors reported that supplementation with 1500mg vitamin C per day compared to < or = 500mg per day increased the anti-inflammatory response and the adrenal stress hormone concentration.[65] Vitamin C supplementation in carbohydrate fed runners did not serve as an antioxidant during or following a competitive ultra marathon race.[74]

Safe dosages of antioxidants for short periods of intense training (5-7days) can possibly have an immune boosting effect.[40] A combination of antioxidants, i.e. 18mg Beta-carotene, 500-1000mg Vitamin C, 60-350mg Vitamin E, 50mg/day Zinc and 5-8g/day of glutamine can be used.[40] Ultra-endurance athletes may benefit from supplementing with <500mg vitamin C per day.[75]

1.6 Other Supplements Used by Endurance Athletes

A dietary supplement is defined by the Dietary Supplementation and Health Act in the USA (DSHEA) as “a product, other than tobacco, which is used in conjunction with a healthy diet and contains one or more of the following dietary ingredients: a vitamin, mineral, herb or other botanical, an amino acid, a dietary substance for use by man to supplement the diet by increasing the total daily intake, or a concentrate, metabolite, constituent, extract, or combinations of these ingredients.” [41]

Supplements form an integral part of the sports nutrition field, with ever increasing elite and amateur athletes spending large amounts of money on supplements with high hopes and believing outrageous claims from supplement manufacturers.

There are different classification systems for sport supplements, including the popular group ABC from the Australian Institute of Sport (AIS) and the Sport Science Institute of South Africa (SSISA).[40] They classify supplements according to its proven benefit, i.e. group A includes supplements with a proven performance benefit like caffeine, creatine, HMB, bicarbonate and carbohydrate. Group B includes supplements currently lacking substantial proof for example, arginine, BCAA, carnitine, co-enzyme Q10 and Group C includes supplements prohibited for use by the IOC like testosterone precursors, nandrolone precursors and stimulants like ephedrine.[40]

1.6.1 Herbal supplements

American, Chinese, Korean and Japanese ginseng belong to the Panax species and are related and found in various amounts in several commercially available supplements.[76] Ginsenosides, known as the active ingredient of ginseng are a number of similar steroid glycosides found in ginseng. In ancient cultures, ginseng is used to relieve pain and headaches, improve cognitive ability as well as the lust for life.[77] Ginseng can reduce the harmful effects of different stressors or act as an adaptogen. An adaptogen can assist to normalize the functioning of the body after an insult or stress.[77,78] Exercise is considered to be a stress and therefore, in athletes, ginseng is used to decrease fatigue and increase aerobic performance, strength, mental alertness and recovery.[79,80,81,82] Clinical trials have failed to show an effect of ginseng on enhancing the immune function, reducing muscle damage, increased psychomotor performance and wellbeing.[83,84,85] However clinical studies fail to support these claims on performance and research supporting the use of ginseng does not include athletes as subjects and cannot be extrapolated to this population.[82,84,86,87,88]

Ephedrine or mahuang is a banned substance for amateur sporting events. Ephedrine *(Ephedra sinica)* and ephedrine alkaloids (ephedrine, pseudoephedrine, nor-ephedrine and norpseudoephedrine) are found commonly in dietary supplements, antiasthmatic bronchodilators, antihistamines, decongestants, appetite suppressants and weight-loss aids.[89,90,91,92] Mahuang or ephedrine and its related alkaloids are sympathomimetic agents and mimic the effect of ephedrine.[90] Adverse effects of ephedrine include nervousness, anxiety, heart palpitations, headaches, nausea, hyperthermia, hypertension, cardiac arrhythmias and even mortality.[90,91,92] However these adverse effects were reported when ephedrine was co-ingested with caffeine as it is commonly found in the same supplements. Ephedrine and its alkaloids had no exercise performance enhancement effect when taken alone in safe dosages (<120mg).[93,94,95,96,97] It had no effect on muscle strength, endurance, lung function, reaction time, hand-eye coordination, anaerobic capacity, speed, cardio respiratory endurance, VO_2 max, ratings of perceived exertion, recovery, fuel homeostasis, ventilation and oxygen consumption.[93,95,97] When ephedrine however is combined with caffeine, an improvement in exercise performance, especially time to exhaustion is seen.[98] In order to prolong the exercise performance effects of the caffeine and ephedrine supplement and to decrease side effects like an increased heart rate and blood pressure, yohimbine is often added to these supplements.[89] Ephedrine with or without caffeine has also been shown to increase the thermogenic ability leading to a decrease in body fat in obese subject and is therefore often added to weight loss supplements.[99,100,101,102,103,104,105,106,107] However, the inclusion of ephedrine containing supplements in the diet of an athlete will lead to positive doping tests and ultimately disqualification from the sport.[89]

Echinacea is commonly used to enhance the immune response in order to reduce the duration and severity of infections, reduce the prevalence of colds and flu, respiratory, middle ear, urinary tract and vaginal yeast infections. It is also linked to healing of skin wounds and inflammation. It is commonly added to dietary supplements containing antioxidants. Barrett 2003.[108] concluded that “while there is a great deal of moderately good-quality scientific data regarding Echinacea, effectiveness in treating illness or in enhancing human health has not yet been proven beyond reasonable doubt.[108,109]

Other herbal supplements include non-coffee herbal sources of caffeine, commonly found in dietary supplements. Ingredients include guarana (Paullinia cupana), kola nut *(Cola acuminata)*, green tea *(Camilla sinensis)* and mate *(Ilex paraguayensis)* and are discussed elsewhere.[89]

1.6.2 Carnitine

Theoretically, carnitine shows a lot of promise, but clinical trials proving the theoretical benefit are currently lacking.. Carnitine, as well as claiming to promote fat loss can theoretically promote energy supply, although this is not supported by experimental evidence. The body of evidence surrounding carnitine supplementation indicates that it does not increase fat oxidation.[41, 110,111,112]

These supplements are often used by female triathletes and can contain herbal ingredients like ephedra, ephedrine and chromium picolinate to aid in the supposed "fat burning" This can be a dangerous practice, not only because the ingredients can have negative side effects, but also because it can lead to positive doping tests.[41,110,111,112] Carnitine plays a role in the transport of fatty acids with acyl-coA into the mitochondria and therefore regulates β-oxidation, which is the process in which fatty acids are broken down by the sequential removal of two carbon units.[7]. Although there is no conclusive evidence, claims include increasing concentration of CoA and stimulating oxidation of fatty acids, hence enhancing performance by increasing β-oxidation and inducing fat loss as fat can be more readily used as a fuel source.[113,114]

1.6.3 Creatine

One of the many promises behind creatine use as an ergogenic aid is the generation of energy during anaerobic exercise and might have neurological and cardio protective effects.[115,116]

Creatine is found naturally in meat and fish and is also a non-protein amino acid produced in the kidney, liver and pancreas from amino-acids including L-arginine, glycine and L-methionine. The synthesized creatine is then transported to the skeletal muscle, heart, brain and tissues where it is metabolized to phospocreatine.[115,116] Phosphocreatine is one of the body's main energy storage forms. Creatine contributes to ATP production, especially during high intensity bouts of exercise over a short period of time.[115,116] It increases high-energy phosphate diffusion within the cell, it can help in reducing intra cellular acidosis during training and the end products of hydrolysis form part of other catabolic reactions.[115,116]

The interaction from creatine and caffeine however limits the use thereof in conjunction.[117] Vandenberghe et al, 1996 found that supplementing 9 healthy male volunteers with creatine (0.5g/kg body weight) elevated muscle phosphocreatine levels and improved performance during short maximal bouts of exercise, the effect was however attenuated by creatine supplementation (0.5g/kg body weight) with added caffeine (5mg/kg body weight).[117] The reason given for this is, is because supplementing with creatine facilitates sarcoplasmic reticulum calcium re-uptake and enhances calcium release from the sarcoplasmic reticulum.[117] Caffeine supplementation attenuates this effect as it is known that caffeine increases calcium losses.[117] Caffeine also interferes with the absorption of creatine.

Supplementation of creatine is usually more applicable in team or strength sport and is of little value in endurance sport like triathlon.[115,116,117]

1.6.4 Caffeine

Caffeine is a popular stimulant found in gels and sports drinks to enhance performance of athletes competing in endurance events.[118] It is impractical for this supplement to be banned as it is widely found in coffee, tea, chocolate, gels and energy drinks in varying amounts of 30-100mg per serving.[119] The International Olympic Committee set an upper limit supplementation dose of caffeine at 12mg/kg body weight.[120] For caffeine to have a beneficial effect on performance, the athlete need to consume 1-3mg/kg body weight of caffeine (50-200mg), whereas 5-6mg/kg body weight can possible have a glycogen sparing effect.[119,120]

The mechanisms for the effect that caffeine has on prolonged submaximal exercise have been linked to an increased utilization of plasma free fatty acids and intramuscular triacylglycerol which in turn reduces the breakdown of glycogen stores. Caffeine is also has an effect on the central nervous system, masking fatigue and prolonging exercise endurance.[121,122,123]

Protocols for caffeine supplementation is traditionally 6mg/kg body weight of caffeine one hour prior to the event, which equates to 350-500mg per athlete.[120] A smaller dosage of caffeine taken at intervals (1-2mg/kg body weight or 70-150mg before and/or throughout exercise or at the end of the race when fatigue sets in) has also been associated with beneficial effects on exercise lasting longer than 60 minutes.[120] Doses exceeding 13mg/kg body weight are associated with an increased risk of side effects including nervousness, shakiness, anxiety, heart palpitations, flushing and headaches.[120,121] The effect of habitual caffeine intake also need to be taken into consideration.[124] When an athlete consumes more than 6 cups of coffee per day, he or she is classified as taking in caffeine on a habitual basis.[124] This reduces the effect that caffeine has on performance.[124] The habitual caffeine drinkers should abstain from ingesting caffeine 4 days prior to the race or competition to ensure effectivity.[124]

Not everyone however responds to caffeine in the same manner and ergolytic effects of caffeine supplementation like the impact on the cardiovascular system, sleep disturbances, increased anxiety and the blocking of erythropotien production have been documented.[125,126,127,128,129,130,131,132,133]

1.6.5 Glucosamine and chondroitin sulphate

Glucosamine and chondroitin sulphate showed a reduction of symptoms like pain relief and slower progression of osteoarthritis of the knee and hip in some people.[134,135,136,137] In a randomized double-blind placebo controlled trial with 212 patients with knee osteoarthritis receiving either 1500mg oral glucosamine sulphate or a placebo daily for three years, the results indicated the group receiving the glucosamine supplementation had reduced joint-space loss and a reduced joint space narrowing in comparison to the placebo group.[138] Reported symptoms in the placebo group were worse than the supplementation group.[138] The investigators concluded that supplementation with glucosamine sulphate could be disease modifying in osteoarthritis.[138] Chondroitin sulphate does appear to have a mildly anti-inflammatory effect, but current evidence is anecdotal and generally lacking.[40,139] The dosage of glucosamine sulphate to be effective is set at 800-1500mg/day and chondroitin sulphate at 200mg/day for a minimum of three months.[40] Above results are however anecdotal, on small sample sizes, over short periods of time [135,136,137,138,139,140] and in general cannot however be extrapolated to the athletic population as evidence in the athletic population is currently lacking.

1.7 Anthropometry and Body Composition

Body composition is a very important aspect of athlete's performance. According to the American Dietetic Association: "body weight can influence an athlete's speed, endurance and power, whereas body composition can affect an athlete's strength, agility and appearance."[12] Improving athletic performance will always be the main goal of athletes. Determining the optimal body weight and body fat for each individual according to age, sex, genetics and type of sport definitely aids in this goal.[12, 141] Therefore, determining an athlete's ideal body fat and weight during peak performance periods is crucial.[142]

Assessment of body composition can be done via various ways. In vivo body composition analysis methods perceived to be the gold standard include direct (neutron activation analysis) and indirect (underwater weighing and Duel energy X-ray absorbtiometry) measures. Prediction equations with the use of a combination of anthropometric measurements (circumferences, breadths and skinfold thicknesses (SKF) and bioelectrical impedance analysis measurements (either 2 component or multi component models) have been compared and validated with the criterion methods.[143,144,145]

According to the literature, there are many prediction equations that can be used to determine body fatness. These equations usually use gender, age or race and skinfold measurements (SKF). This includes equations using 7 SKF (sub scapular, triceps, chest, midaxillary, suprailiac, abdominal and thigh),[146] equations using 4 SKF (abdominal, supra-ileac, thigh and tricep)[147], and equations using 3 SKF (midaxilla, calf and thigh)[147] or using 3 SKF (chest, abdominal and thigh for men, or tricep, supra-iliac and thigh for women).[148] The more popular equation by Durnin and Womersley using body density in combination with skinfold thickness at four sites (bicep, tricep, subscapular and supra-iliac) can also be used.[149]

Bioelectrical Impedance Analysis (BIA) is a method of determining body composition that is reliable, safe, noninvasive and suitable for use in the field.[145] The conduction of an applied constant low level alternating electrical current is used to determine impedance in the human body and is frequency dependent.[150] The human body is made up of intracellular and extracellular fluid compartments that act as conductors of the electrical current and cell membranes are used as electrical condensers (capacitance).[150] Thus, body fluids and electrolytes behave as electrical conductors.[150] Studies have shown that bioelectrical impedance analysis could be a very important tool for the assessment of nutritional status.[150]

There are two types of BIA: Single frequency BIA, (50 kHz) and Multi-frequency BIA (1, 5, 50, 100 and 200 kHz).[145] BIA machines have electrodes that are placed on the hand and on the foot. There is sufficient evidence supporting the use of multi-frequency BIA above single frequency BIA.[145] One of the major differences between single and multi-frequency BIA measures is that single frequency BIA does not measure Total Body Water (TBW), but a weighted sum of extracellular and intracellular water. Single frequency BIA (SF-BIA) is more accurate in determining fat free mass and TBW in well hydrated, healthy subjects and is not validated in persons with altered hydration status.[145] Multi-frequency BIA includes more than one frequency and is more accurate when determining fat free mass, total body water, intracellular and extracellular components.[145] Fat free mass, body fat, body cell mass, total body water, extracellular water and intracellular water can be determined by BIA in subjects with a Body Mass Index (weight/height^2) of 16-34kg/m^2 without abnormal hydration with validated equations for specific age, sex and race.[145]

Ostojic et al. 2006[151] compared the use of skinfold prediction equations with bioelectrical impedance analysis and found similar results for %BF from both methods. (Figure 1.5) Although the conclusion that BIA is superior to SKF methods is inaccurate, one can conclude that it might be a valuable substitute as field method to determine %BF due to the simple, quick and inexpensiveness of BIA.[151] When care is taken with the measurement of anthropometry and bioelectrical impedance analysis and validity and reliability is ensured, measures including body fat and fat free mass can be estimated accurately within 3-4%.[152]

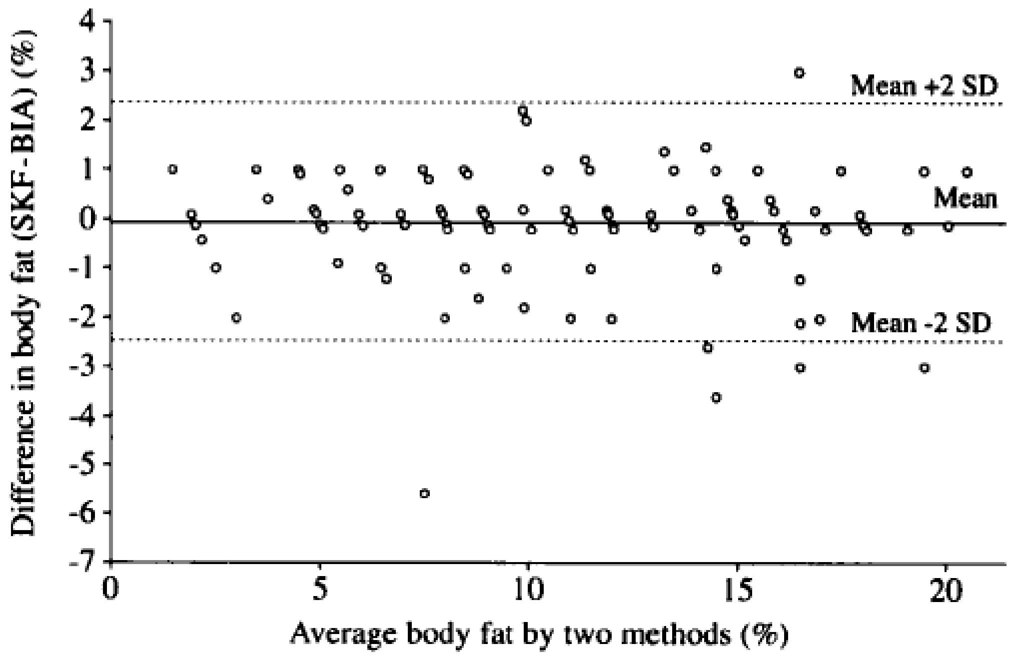

Figure 1.5 Difference between body fat measured with skinfolds (SKF) and bioelectrical impedance analysis (BIA) methods. Data are individual differences between two methods of 219 subjects. Due to overlapping number of dots are less than 219. BF: body fat
Source: Ostojic et al. 2006[151]

1.8 Statement of the Research Question

The literature indicates that nutrition and the determination of nutritional status in athletes is a very important aspect of performance and endurance. A triathlete has to ensure that his/her dietary intake, including the use of supplements, body composition and general immune health are in harmony, not only for groups of athletes, but also specifically tailor made for the individual according to age, gender, ethnicity and genetics. In Southern Africa, no study has investigated these aspects in triathletes competing in olympic and ironman distance events; therefore, the aim of this study was to determine the body composition, dietary intake and supplement use amongst training olympic and ironman distance triathletes residing in the Western Cape region.

The findings of the study will aid in determining the practices triathletes currently follow to achieve an optimal level of performance. This study could also form the basis for larger, national studies in order to increase the current nutrition knowledge of triathletes, help them determine their own individual optimal nutritional status, and enable them to improve their endurance performance.

CHAPTER 2: METHODOLOGY

2.1 Aim

The aim of this study was to determine the body composition, dietary intake and supplement use among training olympic and ironman distance triathletes residing in the Western Cape region.

2.2 Objectives

2.2.1 Determine the anthropometric status of olympic and ironman distance endurance triathletes residing the Western Cape region.

2.2.2 Determine body composition of olympic and ironman distance endurance triathletes via multi-frequency bio-electrical impedance analysis residing in the Western Cape region.

2.2.3 Compare the percentage body fat of these athletes as determined by anthropometry and multi-frequency bio-electrical impedance analysis.

2.2.4 Analyze and assess the adequacy of the habitual dietary intake of endurance triathletes.

2.2.5 Determine the intake and attitude regarding the use of dietary supplements and nutritional ergogenic aids.

2.2.6 Determine clinical health status of the triathletes.

2.2.7 Determine whether there is an association between anthropometry, body composition, and dietary and supplement intake in relation to clinical health status.

2.3 Study Design

Descriptive, analytical cross-sectional study design.[153]

2.4 Study Population

Triathletes residing in the Western Cape region registered with Triathlon South Africa (TSA) were included in the study population. The Western Province Triathlon team (WPTA) of 2007 consisted of 61 athletes and the 2008 team of 53 athletes. Many of these athletes were selected for both the 2007 and 2008 team (91 in total). It is compulsory for triathletes to be registered with the TSA and triathletes can also belong to one of the four triathlon clubs in the Western Cape region. Twenty six of these 91 were recruited by sending out an e-mail to all registered triathletes using the WPTA database. The database included all the athletes in the WPTA 2006 and 2007 squad. An advertisement was also placed on the WPTA website (http://www.wptriathlon.org). A reminder notice to participation was also sent out via the database and placed on the website midway during the data collection phase in order to achieve the maximum possible voluntary participation in the study. An advertisement as well as a reminder midway during the data collection phase was also placed in the Western Cape's leading multi sport magazine as well as sent out via their database. The investigator also distributed pamphlets with information regarding the research project at the following triathlon races during 2007, Spec savers Ironman South Africa 2007, WPTA triathlon trials 2007, WPTA triathlon championship 2007, TSA triathlon championship 2007, Clanwilliam triathlon 2006 and 2007 and Jailbreak triathlon 2007. The investigator also had an exhibition at the Jailbreak triathlon 2007 from where subjects were recruited and participated on site. The reason for distributing pamphlets at the Spec savers Ironman South Africa 2007 was due to the fact that the inclusion criteria included athletes from the WPTA as well as athletes who have completed an ironman distance event in the 6 months prior to data collection.

2.5 Inclusion Criteria

The inclusion criteria for participation in the research project were:

2.5.1 Male or female triathletes between the ages 18 to 70 years were included

2.5.2 Triathletes on the WPTA team 2007 and 2008 and who were training more than 10 hours per week, including swimming, cycling and running

2.5.3 Triathletes who completed an ironman distance event 6 months prior to data collection and who were training more than 10 hours per week including swimming, cycling and running

2.6 Exclusion Criteria

Triathletes who were not included in the research project include triathletes not adhering to the pre-test conditions, not adhering to the inclusion criteria, did not respond to the invitation to participate or the triathletes who did not give written consent.

2.7 Methods of Data Collection

The data collection phase was during the South African Triathlon season from June 2007 to March 2008. The investigator saw the participating subjects at their convenience either at a private dietetic practice in Strand, Western Cape, at the subject's home, a nearby gym or at the triathlon events.

2.7.1 Anthropometric measurements

The heights of the subjects were measured using a Seca 767 Column Scale with height meter. The heights of the subjects were measured according to specifications from the literature.[154] The subjects stood barefoot with minimal clothing and all hair ornamentation were removed. Subjects stood with heels together, arms to the side, legs straight, and shoulders relaxed with head in the Frankfort horizontal plane. The heels, buttocks, scapulae (shoulder blades) and back of the head was against the vertical surface of the height meter. The subjects inhaled deeply just before measurement was taken. The breath was held and an erect posture was maintained while the headboard was lowered on the highest point of the head with enough pressure to compress the hair. Measurements were read to the nearest 0.1cm and with the eye level with the headboard to eliminate errors caused by parallax. Three measurements were taken and in the case of a measurement not agreeing, another measurement was taken to eliminate any source of error. The average of the three measurements was used for data analysis.

The weight of the subjects was measured using a Seca 767 Column Scale with height meter. The measurements were taken according to standard anthropometric procedure.[154] The subjects stood still in the middle of the platform without touching anything and with the body weight equally distributed on both feet. The weight measurement was read to the nearest 100g and recorded. The subjects wore light clothing and no shoes and were asked to empty the bladder before the measurement was taken. The subjects were asked not to consume any food or beverage for 3-4 hours prior to data collection. Subjects seen at triathlon events were also instructed to be fasted for 3-4 hours. This practice was only followed by one triathlon event, i.e. Clanwilliam Fitness Festival, were the race was scheduled for the afternoon and the researcher collected the data from the subjects in the morning, after an overnight fast and no exercise. In the event of the subjects not adhering to the criteria, another date was set for data collection. Three measurements were taken and in the case of a measurement not agreeing, another measurement was taken to eliminate any source of error. The average of the three measurements was used for data analysis.

The frame size of the subjects were measured using a ISO9001:2000 Digital Vernier Caliper according to the standard anthropometric measurement technique.[154] The subjects stood upright with the right arm in a horizontal position with the elbow stretched to form a 90 degree angle in relation to the fore arm, with fingers up. The observer stood with the subject facing him/her. The back of the hand was toward the person taking the measurement. The distance between the lateral and medial epicondyles were measured, with the caliper blades vertical in relation to the floor. The measurement was taken to the nearest mm. Three measurements were taken and in the case of a measurement not agreeing, another measurement was taken to eliminate any source of error. The average of the three measurements was used for data analysis.

The waist and hip circumference were measured with a two meter anatomical measuring tape. Both the measurements were taken without clothes and the subjects were standing upright. The waist circumference was measured as the minimal circumference midway between lower rib margin and superior anterior iliac spine and the measuring tape was placed horizontally across without cutting into the skin.[154] The measurement was taken at the end of normal exhalation. The hip circumference was taken as the maximal circumference at the level of the trochanters.[154] The subjects were wearing underwear when taking the hip circumference. The measuring tape was placed horizontally across the trochanters, without cutting into the skin. Three measurements were taken and in the case of a measurement not agreeing, another measurement was taken to eliminate any source of error. The average of the three measurements was used for data analysis.

2.7.2 Skinfold thickness measurements

The bicep, tricep, sub-scapular, supra-iliac, abdominal, chest, mid-axilla, thigh and calf skinfold thickness were measured with a Dial Gauge Harpenden Skinfold Caliper. Three skinfold measurements were taken at each individual site and the mean calculated for use in data analysis. In the case of measurements not agreeing, (>1mm), the measurement was repeated. All the anatomical sites were found as indicated for each individual skinfold thickness in the literature.[154] All measurements were taken on the right side of the body and a non-stretchable tape measure used to determine midpoints and anatomical sites. The caliper was checked for accuracy and zero calibrated before every measurement. The skinfold was taken firmly between the thumb and the index finger, 1cm above the skinfold site. The caliper was placed in the middle of the skinfold and a measurement was read four seconds after releasing the skinfold calipers. The measurement was taken to the nearest millimeter.

2.7.3 Body composition

The body composition of the subjects were measured using a Bodystat Quadscan 4000SN (5 kHz, 50 kHz, 100 kHz and 200 kHz) Isle of Mann, 2000 multi-frequency bioelectrical impedance meter. The MF-BIA was calibrated weekly during the data collection phase as described in the user manual using the BODYSTAT calibrator supplied.[155]

Subjects were asked to remove all jewelry, watches and belts that may interfere with the reading. Subjects were instructed to remove the right shoe and sock as well as clear the hand and wrist area. Subjects were asked to be in the fasted state for 3-4 hours and to have abstained from exercising for 12 hours prior to taking the measurement. They were asked to not consume any alcohol or caffeine for 24 hours prior to the data collection session. The subjects were asked to lie in the supine position on a plinth for approximately 5 minutes before taking the measurement to stabilize fluid levels. No parts of the body were touching one another. The areas of the skin where the electrodes were placed were prepared with isopropyl alcohol before placing the electrodes. All the measurements were taken inside a building at normal room temperature. Electrodes were placed as described by the manufacturer in the instruction manual.[155] Two distal electrodes were placed on the dorsal surfaces of the hand and the foot, proximal to the metacarpal phalangeal and the metatarsal phalangeal joints respectively. Two electrodes were also placed on the pisiform prominence of the wrist and between the medial and lateral malleoli of the ankle. The leads were connected to the electrodes and the measurement performed. The red leads were connected to the electrodes behind the right finger and toe and the black leads were connected to the electrodes on the right wrist and right ankle.

2.7.4 Dietary intake

Dietary intake was measured using a 3 day estimated food record (Appendix 2.1). During the consultation with the subjects, the investigator carefully explained the process of keeping a food record. The subjects were asked to weigh their portion sizes or record the portions as seen on the food labels (e.g. one can of cold drink). If they were not able to weigh the food and the portion size was not known, they were given a 15cm clear ruler to take the diameters of the food product. The subjects were also allowed to write the portions in household measurements. (e.g. one cup of rice). The subjects were instructed to not deviate from their normal dietary intake and to record detailed information. The subjects signed a declaration on the food record stating that the information given was an accurate reflection of what they had eaten. The subjects were asked to include two weekdays and one weekend day in the food record. The food record also contained a section were the subjects were instructed to record daily supplement use. They were asked to include brand names, frequency and dosage of supplementation as well as reasons for taking the specific supplement. The investigator gave the subjects the food record booklet (Appendix 2.1), the 15cm ruler and a prepaid self-addressed envelope for mailing the food record back to the investigator.

2.7.5 Clinical health status

The subjects completed the standardized United States Olympic Committee Athlete profile medical history questionnaire (Appendix 2.2).[156] Previous versions of the questionnaire have been used in studies on the prevalence of asthma in the 1996 summer olympic games and the 1998 winter olympic games.[157,158] Further validation of the questionnaire has not been published. The only change made in the questionnaire was the inclusion of an appendix containing questions on exercise frequency and intensity, smoking habits and alcohol use as well as gastro-intestinal complications. The appendix to the medical health questionnaire was tested for face and content validity with 2 members of the Strand athletic club. This enabled the investigator to establish whether or not the athletes gave the answers the questionnaire was designed for. The complete questionnaire was not validated in the pilot study, as it is a widely used questionnaire and specific for the athletic population. The subjects completed the questionnaire in the presence of the investigator which ensured that quality information was obtained. Instructions were given beforehand on how to complete the questionnaire and any additional questions or explanation of terms were answered by the investigator while the subjects completed the questionnaire.

2.8 Data Analysis

All data was entered into a spreadsheet on Microsoft Excel. With the help of the statistician the data was transferred to Statistica 8.0 for statistical analysis.

2.8.1 Body mass index

The body mass index (BMI) of the subjects was calculated using the formula: BMI = Weight/Height.^{2} The BMI of the subjects were interpreted according to the World health organization's guidelines. (Table 2.1)[159]

Table 2.1 World health organization classification of body mass index

Classification	BMI(kg/m^2)	
	Principal cut-off points	Additional cut-off points
Underweight	**<18.50**	**<18.50**
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	**18.50 - 24.99**	**18.50 - 22.99**
		23.00 - 24.99
Overweight	**≥25.00**	**≥25.00**
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	**≥30.00**	**≥30.00**
Obese class I	30.00 - 34-99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004[159]

2.8.2. Skinfold measurements

When taking skinfold thickness measurements, the assumptions made include that subcutaneous fat tissue has a constant compressibility, the skin thickness is minimal, the thickness of the skinfold is constant and can be determined between individuals and that the fat content of adipose tissue is constant.[154] It also assumes that the ratio between the external and internal fat tissue is constant and that body fat is normally distributed.[154]

2.8.3 Determining percentage body fat from skinfold prediction equations

2.8.3.1 Skinfold prediction equation by Durnin and Womersley[144]

The percentage body fat was calculated using a skinfold prediction equation incorporating skinfold thickness at four anatomical sites, bicep, triceps, subscapular and supra-iliac, gender, age and weight. The first step was to calculate the sum of the four skinfold thickness measurements. The logarithm of the sum of the four SKF thickness measurements were calculated and the Siri 1956 equations were applied to compute the body density (table 2.2).[160] Fat mass and percentage body fat were calculated by the following equations:

Fat mass (kg) = body weight (kg) X (4.95/D – 4.5)

%BF = Fat mass (kg)/Body weight (kg)

Table 2.2 Equations for determining body density

Men:	Women:
17-19 D = 1.1620 – 0.0630 X (log Σ4SKF)	17-19 D = 1.1549 – 0.0678 X (log Σ4SKF)
20-29 D = 1.1631 – 0.632 X (log Σ4SKF)	20-29 D = 1.1599 – 0.0717 X (log Σ4SKF)
30-39 D = 1.1422 – 0.0544 X (log Σ4SKF)	30-39 D = 1.1423 – 0.0632 X (log Σ4SKF)
40-49 D = 1.1620 – 0.0700 X (log Σ4SKF)	40-49 D = 1.1333 – 0.0612 X (log Σ4SKF)
50+ D = 1.1715 – 0.0779 X (log Σ4SKF)	50+ D = 1.1339 – 0.0645 X (log Σ4SKF)

Source: Siri, WE. The gross composition of the body. 1956;4:239[160]

2.8.3.2 Skinfold prediction equation by Evans et al. 2005[146]

The percentage body fat was calculated using the prediction equation based on the four component model, incorporating skinfold thickness at 7 anatomical sites, subscapular, triceps, chest, midaxillary, supra-iliac, abdominal, thigh, gender and race.

%BF = 10.566 + 0.12077(7SKF) – 8.057(gender) – 2.545(race)

(Where gender: 0=Female and 1=Male and Race :> 0=White and 1 = Black)

2.8.3.3.Skinfold prediction equation by Evans et al. 2005[146]

The percentage body fat was calculated using the prediction equation based on the four component model using skinfold thickness at 3 anatomical sites, midaxilla, calf, thigh, gender and race.

%BF = 8.997 + 0.24658(3SKF) – 6.343(gender) – 1.998(race)

(Where gender: 0=Female and 1=Male and Race: > 0=White and 1 = Black)

2.8.3.4.Skinfold prediction equation by Jackson and Pollock 1985[147]

The percentage body fat was calculated using a gender specific equation incorporating skinfold thickness at 4 anatomical sites, abdomen, supra-iliac, thigh, triceps and age.

Men: %BF = 0.29288(4SKF) – 0.0005(4SKF2) + 0.15845(age) – 5.76377

Women: %BF = 0.29669(4SKF) – 0.00043(4SKF2) + 0.2963(age) + 1.4072

2.8.3.5. Skinfold prediction equation by Jackson and Pollock 1985[147]

The percentage body fat for men only was calculated using the prediction equation based on skinfold measurements from three anatomical sites, abdomen, supra-iliac, triceps and age.

%BF = 0.39287(3SKF) – 0.00105(3SKF2) + 0.15772(age) – 5.18845

2.8.3.6.Body byte® Pro V3.20. Body and Nutrition Manager software program[148]

The percentage body fat was calculated using a nutrition software program on the computer. Demographic information is entered into the program, age, gender, weight and height. The chest, abdomen and thigh skinfold measurements were entered to calculate the percentage body fat for men and the tricep, supra-iliac and thigh skinfold thickness measurements were entered to calculate the women's percentage body fat.

2.8.4 Body composition analysis

Demographic information was entered into the MF-BIA, weight, height, age, gender, activity level (Table 2.3),[155] waist circumference and hip circumference. An activity level of VERY HIGH was selected for all subjects. MF-BIA was used to determine the percentage body fat of the athletes.

Table 2.3 Description of activity level entered into the MF-BIA

Activity level	General	Activities
Very Low: movement restricted	Generally inactive	Laying at ease, sitting, writing, standing, driving
Low/Medium: office/ light work	Recreational activities for short duration, low intensity	Cycling (9kph), bowling, golf, hiking, tennis, walking (4kph)
Medium: weekend recreation	Sporadic involvement in recreational activities for short duration and at moderate intensity	Low intensity aerobics, badminton, cycling (114kph), light gymnastics, alpine skiing, swimming, competitive tennis, ballroom dancing
Medium/High: moderate exercise	Moderate job activity and moderate exercise 3 times per week	Basketball, cycling (18-22kph), vigorously canoeing, disco dancing, martial arts, handball, rope skipping, running (8-10kph), walking (8-10kph)
Very High: Vigorous exercise, competitive	**Consistent job activity and vigorous exercise 4 times per week**	**High intensity aerobic exercise, cycling (24-32kph), circuit weight training, calisthenics, field hockey, heavy gymnastics, squash, ice hockey, handball, racquetball, rope skipping, soccer, running (11-14kph), cross country skiing, swimming (46-64metres/min)**

Source: User's guide for Quadscan 4000 (Isle of Man) Body Composition and fluid measuring devices, 2000[155]

2.8.5 Dietary analysis

The three day food records were analyzed by the investigator using the Food Finder III computer software.[161] If the specific food item could not be located on the computer program, the food composition[162] and quantities[163] manuals were used or the macronutrient composition of the food items were taken from the nutritional label of the product and added to the analysis. The only food items added to the Food Finder analysis were liquid meal replacements which could not be accurately analyzed on the food finder database.

Portion sizes were entered as the subjects recorded it in the food record booklet. Food Finder III gives portions as either household measures, in diameters or it allows for the investigator to enter the exact weight as written by the subject. The subjects were asked to record all ingredients of meals (e.g. all ingredients in lasagna) and in the case of the recipe not correlating with the standard recipe in Food Finder III, the single ingredients were entered.

2.9 Statistical Analysis

Analysis of results were completed using Statistica 8 and Microsoft Excel XP. Due to the descriptive and informative nature of the study, mostly descriptive statistics in the form of mean and standard deviation (SD) for nominal data and percentages of the total population for ordinal data was calculated to determine the central tendency.

When repeated measures were compared to one another, repeated measures analysis of variance (ANOVA) was used. The technique of bootstrapping was applied to estimate sample distributions for data from a bivariate normal distribution and the post hoc Bonferroni test was applied to determine the significant differences between group means during analysis of variance, making it more difficult to be statistically significant. ($p < 0.01$)

Associations between nominal data were determined using t-test for independent variables and the chi-square test between ordinal data or percentages. Non-parametric Mann-Whitney U and Spearmen R correlation coefficient tests were performed for data measured on an ordinal or rank order scale. Statistical significance were set at a p value of less than 0.05.

CHAPTER 3: RESULTS

3.1 Demographic Information

The 2006 and 2007 WPTA team consisted of 65 and 50 athletes respectively. The total number of athletes included in this study was 26 triathletes who met the inclusion criteria and consented to participate. Of the 26 athletes, 13 were male and 13 female. The mean age of the study population was 37.7 [Standard Deviation (SD) 8.2] years. The mean age of the men was 37.9 (6.8) and the women was 37.5 (9.6) years (Table 3.1). The athletes ranged from elite (*N* = 3) to amateur (*N* = 23) triathletes. All the athletes were Caucasian, except for one male participant who was of the Colored ethnic group. The mean height measured was 1.8 (0.1) m and 1.7 (0.1) m for men and women respectively. The mean body weight of the women was 63.9 (10.3) kg and 78.9 (12.9) kg for men. The mean BMI was 24.5 (3.2) kg/m^2 for men and 22.6 (2.8) kg/m^2 for women, which is within the normal ranges as classified by the World Health Organization.[159] There were a significant difference between the mean height (t = 3.98; p = 0.001) and weight (t = 3.3; p = 0.003) of the male and female athletes, but no significant difference between the body mass indices (t = 1.6; p = 0.13, see Table 3.1).

Interestingly, 62% (*N* = 16) of all the triathletes indicated that they were not satisfied with their current weight and would like to weigh less than they did at the time of data collection. Although there were no significant difference, the majority that indicated they were unsatisfied with their weight were women (38%) (*N* = 5). Twenty three percent (*N* = 3) of the men were not satisfied with their weight. (chi-square; p = 0.1). Thirty percent (*N* = 8) of the triathletes indicated that they had to lose weight regularly to meet the requirements for the triathlon. There were no significant difference between the men (12%) (*N* = 2) and the women (15%) (*N* = 2) (chi-square; p = 0.7).

The mean waist circumference and waist to hip ratio of the men and women respectively were 84.8 (9.5) cm and 0.9 (0.1) and 76.2 (6.4) cm and 0.8 (0.1), and were well below the cut off values set by the World Health Organization for an increased risk of developing chronic diseases of lifestyle. There were significant differences between the male and female athletes in waist circumference (t = 2.7; p = 0.01) and the waist to hip ratio (t = 4.2; p = 0.0004).

The average amount of training per week for males and females respectively were 15.1 (4.1) and 15.3 (4.7) hours. As most of the time during a triathlon is normally spent on the cycling segment of the triathlon, the athletes spend more of their time cycling, 6.5 (2.0) and 6.4 (2.5) hours per week for men and women respectively. The mean time spent on running was 4.2 (2.4) hours per week for men and 4.3 (1.7) hours per week for women, and the mean time spent on swimming were 3.5 (2.1) hours per week for men and 4.2 (2.5) hours per week for women. No significant difference was found between total hours training per week (t = -0.1; p = 0.9), the time spent cycling (t = 0.1; p = 0.9), running (t = -0.1; p = 0.9) or swimming (t = -0.7; p = 0.5) between the men and women. The distances the athletes completed in the time spent training per week indicated their intensity of training and were for men and women respectively, 173.8 (68.1) and 188.9 (88.5) km per week cycling, 39.6 (17.9) and 41.5 (16.6) km per week running, and 6.4 (2.6) km and 10.2 (5.9) km per week swimming. There were no significant differences between men and women in the distance covered by cycling (t = -0.5; p = 0.6) and running (t = -0.3; p = 0.8) per week. However the distance covered by swimming did differ significantly (t = -2.1; p = 0.01 see Table 3.1) with women having covered a longer distance. Most athletes had two training sessions per day as it was very difficult to master three disciplines with one training session per day. A training session could also be a session where two disciplines were exercised in the same training session, e.g. a brick session; or going for a run directly after finishing the cycling training session.

The training intensity of the male triathletes were, swimming 2.0 (0.6) km/hour, cycling 27.6 (7.8) km/hour and running 10.5 (3.7) km/hour and the female triathletes were swimming 2.5 (0.8) km/hour, cycling 28.9 (7.7) km/hour and running 10.1 (4.0) km/hour. There were no significant differences in the training intensity for swimming (t = 0.6; p = 0.1), cycling (t = 0.4; p = 0.7) and running (t = 0.3; p = 0.8) between the male and female triathletes.

Table 3.1 Mean (standard deviation) demographic characteristics of the triathletes by gender.

Athletes Characteristics	Male Mean (SD) (*N*= 13)	Female Mean (SD) (*N* = 13)	t-test; p value
Demographic characteristics			
Age (years)	37.9 (6.8)	37.5 (9.6)	t = 0.1; $p > 0.05$
Anthropometric characteristics			
Height (m)	1.8 (0.1)	1.7 (0.1)	t = 3.98; p = 0.001
Body Weight (kg)	78.9 (12.9)	63.9 (10.3)	t = 3.3; p = 0.003
Body Mass Index (kg/m^2)	24.5 (3.2)	22.6 (2.8)	t = 1.6; p = 0.1
Waist Circumference (cm)	84.8 (9.5)	76.2 (6.4)	t = 2.7; p = 0.01
Hip Circumference (cm)	99.5 (7.9)	98.5 (8.3)	t = 0.3; p = 0.7
Waist/Hip ratio	0.9 (0.1)	0.78 (0.1)	t = 4.2; p = 0.0004
Training characteristics			
Total hours training per week	15.1 (4.1)	15.3 (4.7)	t = -0.1; p = 0.9
Swimming (hours)	3.5 (2.1)	4.2 (2.5)	t = -0.7; p = 0.5

Table 3.1 Mean (standard deviation) demographic characteristics of the triathletes by gender (continued).

Athletes Characteristics	Male Mean (SD) (*N*= 13)	Female Mean (SD) (*N* = 13)	t-test; p value
Training characteristics			
Bicycling (hours)	6.5 (2.1)	6.4 (2.5)	t = 0.1; p = 0.9
Running (hours)	4.2 (2.4)	4.3 (1.7)	t = -0.1; p = 0.9
Gym/Resistance training (hours)	0.9 (1.1)	0.5 (0.9)	t = 1.1; p = 0.3
Swimming (km)	6.4 (2.6)	10.2 (5.9)	t = -2.1; p = 0.01
Bicycling (km)	173.8 (8.1)	188.9 (88.5)	t = -0.5; p = 0.6
Running (km)	39.6 (17.9)	41.5 (16.6)	t = -0.3; p = 0.8
Training intensity			
Swim intensity (km/hour)	2.0 (0.6) (*N* = 11)	2.5 (0.8) (*N* =12)	t = 0.6; p = 0.1
Cycle intensity (km/hour)	27.6 (7.8) (*N* = 12)	28.9 (7.7) (*N* = 11)	t = 0.4; p = 0.7
Run intensity (km/hour)	10.5 (3.7) (*N* = 11)	10.1 (4.0) (*N* = 12)	t = 0.3; p = 0.8

*One male subject neglected to complete the appendix to the medical history questionnaire and did not respond to correspondence asking to complete it.

3.2 Anthropometry

The mean skinfold thicknesses for men and women respectively were for bicep 4.9 (1.68) and 9.5 (6.9), tricep 8.6 (3.2) and 17.3 (9.99), subscapular 12.5 (5.8) and 11.2 (4.8), supra-iliac 10.6 (5.8) and 13.3 (6.1), chest 10.6 (6.3) and 11.2 (6.5), mid-axilla 10.8 (6.2) and 12.7 (6.3), thigh 12.3 (5.7) and 23.1 (12.3), abdominal 17.0 (9.3) and 16.7 (7.5) and calf 8.6 (1.8) and 16.9 (7.4) mm (Table 3.2). There were significant differences in the bicep (t = -2.3; p = 0.03), tricep (t = -2.99; p = 0.01), thigh (t = -2.8; p = 0.01) and calf (t = -3.6; p = 0.002) skinfold measurements between the men and women. The skinfold measurements were used to calculate percentage body fat with the selected prediction equations.

Table 3.2 Mean (standard deviation) anthropometric variables of the triathletes by gender.

Anthropometric variables	**Male Mean (SD) (*N*= 13)**	**Female Mean (SD) (*N* = 13)**	**t-test; p value**
Skinfold measurements			
Bicep skinfold (mm)	4.9 (1.7)	9.5 (6.9)	t = -2.3; p = 0.03
Tricep skinfold (mm)	8.6 (3.2)	17.3 (9.99)	t = -2.99; p = 0.01
Subscapular skinfold (mm)	12.5 (5.7) (*N* = 12)*	11.2 (4.8)	t = 0.6; p = 0.6
Supra-iliac skinfold (mm)	10.6 (5.8)	13.3 (6.1)	t = -1.2; p = 0.3

Table 3.2 Mean (standard deviation) anthropometric variables of the triathletes by gender (continued).

Anthropometric variables	Male Mean (SD) (*N*= 13)	Female Mean (SD) (*N* = 13)	t-test; p value
Skinfold measurements			
Chest skinfold (mm)	10.6 (6.3)	11.2 (6.5)	t = -0.2; p = 0.8
Mid-axilla skinfold (mm)	10.8 (6.2)	12.7 (6.3)	t = -0.8; p = 0.4
Thigh skinfold (mm)	12.3 (5.7)	23.1 (2.3) (*N* = 11)*	t = -2.8; p = 0.01
Abdominal skinfold (mm)	17.0 (9.3)	16.7 (7.5) (*N* = 11)*	t = 0.1; p = 0.9
Calf skinfold (mm)	8.6 (1.8) (*N* = 11)*	16.9 (7.4) (*N* = 12)*	t = -3.6; p = 0.002

*Respective skinfold thickness could not be obtained in a number of the male and female athletes due to variation in skin compressibility and an increased muscle mass, making the skinfold thickness difficult and inaccurate to measure.

3.3 Percentage Body Fat

Prediction equations and MF-BIA to determine percentage body fat were used to determine body fatness of the triathletes (Table 3.3). The equations differed by using a different collective number and type of skinfold measurements as well as adding either body density, gender, age or race in the equation. The typical percentage body fat of elite male triathletes is documented to be between 6-10% and for women between 11-18%.[164]

The different %BF values for men and women respectively differed significantly and were %BF from the MF-BIA measurement 12.6 (4.2) and 22.3 (6.3) (t = -4.3; p = 0.0004), %BF from the Durnin and Womersley eqauation[149], 17.5 (5.5) and 29.97 (7.2) (t = -4.5; p = 0.0002), %BF from the 7 SKF site equation from Evans et al. 2005[146], 12.6 (4.4) and 24.2 (6.1) (t = -5.1; p = 0.0001), %BF from the 3 SKF site equation from Evans et al. 2005[146], 9.4 (2.96) and 22.9 (6.6) (t = -6.3; p = 0.00001), %BF from the 4 SKF site equation from Jackson and Pollock 1985[147], 12.1 (4.9) and 32.4 (8.95) (t = -6.6; p = 0.000002), the 3 SKF site equation from Jackson and Pollock 1985[147] for men only, 12.5 (4.9) and the %BF from the Body bite computer software program[148], 11.7 (5.2) and 23.4 (8.95) (t = -3.8; p = 0.01) respectively (Table 3.3).

The influence of the level of competition the triathletes are taking part in, as well as the influence of the duration of the competition need to be taken into consideration when interpreting %BF measures. Although the sample size is small, the %BF from MF-BIA of the male amateur ultra-distance athletes were 14.7 (3.9) (*N* = 7) and female amateur ultra-distance athletes were 24.4 (6.0) (*N* = 7) (t = 3.6; p = 0.004), the male amateur olympic distance athletes were 11.4 (4.3) (*N* = 5) and female amateur olympic distance athletes were 16.7 (5.7) (*N* = 7) (t = 1.5; p = 0.2), the male elite olympic distance athletes had a %BF of 8.7 (*N* = 1) and the female elite olympic distance athletes 18.2 (5.7) (*N* = 2) (t = 3.4; p = 0.2). (Table 3.3)

Table 3.3 Mean (standard deviation) percentage body fat of the triathletes by gender

Percentage body fat variables	Male Mean (SD) (*N* = 12)*	Female Mean (SD) (*N* = 9)*	t-test; p value
Reference range[164]	**6-10%**	**11-18%**	**N/A**
MF-BIA			
Bodystat Quadscan 4000	12.6 (4.2)	22.3 (6.3)	t = -4.3; p = 0.0004
Skinfold prediction equations			
Durnin and Womersley[149]	17.5 (5.5)	29.97 (7.2)	t = -4.5; p = 0.0002
Evans et al 2005[146] (7 SKF sites)	12.6 (4.4)	24.2 (6.1)	t = -5.1; p = 0.0001
Evans et al 2005[146] (3 SKF sites)	9.4 (2.96)	22.9 (6.6)	t = -6.3; p = 0.00001
Jackson and Pollock 1985[147] (4 SKF sites)	12.1 (4.9)	32.4 (8.95)	t = -6.7; p = 0.000002
Jackson and Pollock 1985[147] (3 SKF sites, men only)	12.5 (4.9)	(*N* =0)	Not applicable
Body bite Pro[148]	11.7 (5.2)	23.4 (8.95)	t = -3.4; p = 0.001

*Prediction equations could not be determined from subjects due to SKF measurements not obtained from subjects due to variation in skin compressibility and an increased muscle mass, making the skinfold thickness difficult and inaccurate to measure.

Table 3.4 Mean (standard deviation) percentage body fat of the triathletes according to gender and level and duration of competition.

Percentage body fat variables	Male Mean (SD)	Female Mean (SD)	t-test; p value
Reference range[164]	**6-10%**	**11-18%**	**N/A**
MF-BIA (Bodystat Quadscan 4000)			
Amateur ultra-distance athletes	14.7 (3.9) (*N* = 7)	24.4 (6.0) (*N* = 7)	t = 3.6; p = 0.004
Amateur olympic distance athletes	11.4 (4.3) (*N* = 5)	16.7 (5.7) (*N* = 3)	t = 1.5; p = 0.2
Elite olympic distance athletes	8.7 (*N* = 1)	18.2 (2.3) (*N* = 2)	t = 3.4; p = 0.2
Durnin and Womersley[149]			
Amateur ultra-distance athletes	19.8 (4.7) (*N* = 7)	32.2 (5.7) (*N* = 8)	t = 4.6; p = 0.0005
Amateur olympic distance athletes	14.5 (6.2) (*N* = 4)	23.5 (0.5) (*N* = 3)	t = 2.4; p = 0.1
Elite olympic distance athletes	13.4 (*N* = 1)	21.8 (1.9) (*N* = 2)	t = 3.5; p = 0.2
Evans et al. 2005 (7 SKF sites)[146]			
Amateur ultra-distance athletes	13.8 (4.8) (*N* = 7)	25.3 (6.6) (*N* = 7)	t = 3.8; p = 0.003
Amateur olympic distance athletes	11.7 (3.6) (*N* = 4)	19.9 (*N* = 1)	t = 2.0; p = 0.1

Table 3.4 Mean (standard deviation) percentage body fat of the triathletes according to gender and level and duration of competition (continued).

Percentage body fat variables	Male Mean (SD)	Female Mean (SD)	t-test; p value
Reference range[164]	**6-10%**	**11-18%**	**N/A**
Evans et al. 2005 (7 SKF sites)[146]			
Elite olympic distance athletes	7.9 (*N* = 1)	19.7 (2.95) (*N* = 2)	t = 3.3; p = 0.2
Evans et al 2005. (3 SKF sites)[146]			
Amateur ultra-distance athletes	10.6 (2.95) (*N* = 7)	22.7 (7.6) (*N* = 8)	t = 3.9; p = 0.002
Amateur olympic distance athletes	9.4 (4.9) (*N* = 5)	16.7 (3.3) (*N* = 3)	t = 2.3; p = 0.06
Elite olympic distance athletes	8.3 (*N* = 1)	19.6 (0.5) (*N* = 2)	t = -20.3; p = 0.03
Jackson and Pollock 1985 (4 SKF sites)[147]			
Amateur ultra-distance athletes	14.2 (4.4) (*N* = 7)	33.3 (9.2) (*N* = 8)	t = 5.0; p = 0.0002
Amateur olympic distance athletes	12.8 (7.5) (*N* = 5)	22.0 (3.4) (*N* = 3)	t = 1.96; p = 0.1
Elite olympic distance athletes	6.2 (*N* = 1)	24.9 (0.9) (*N* = 2)	t = -17.6; p = 0.04

Table 3.4 Mean (standard deviation) percentage body fat of the triathletes according to gender and level and duration of competition (continued).

Percentage body fat variables	Male Mean (SD)	Female Mean (SD)	t-test; p value
Reference range[164]	**6-10%**	**11-18%**	**N/A**
Jackson and Pollock 1985 (3 SKF sites MEN ONLY)[147]			
Amateur ultra-distance athletes	14.5 (4.4) (*N* = 7)	N/A	N/A
Amateur olympic distance athletes	13.2 (7.1) (*N* = 5)	N/A	N/A
Elite olympic distance athletes	6.1 (*N* = 1)	N/A	N/A
Bodybite nutrition software program[148]			
Amateur ultra-distance athletes	13.7 (5.0) (*N* = 7)	24.8 (9.7) (*N* = 7)	t = 2.7; p = 0.02
Amateur olympic distance athletes	12.9 (8.2) (*N* = 5)	18.8 (0.4) (*N* = 2)	t = 0.95; p = 0.4
Elite olympic distance athletes	5.5 (*N* = 1)	17.1 (2.8) (*N* = 2)	t = -3.4; p = 0.2

Although there were a significant difference in the values obtained from the different measures of %BF for male and female athletes (Table 3.3), a general tendency was observed with the different methods in male and female triathletes in comparison with

MF-BIA as illustrated with the least square means (Figure 3.1) (F (5, 95) = 13.7; p = 0.0).

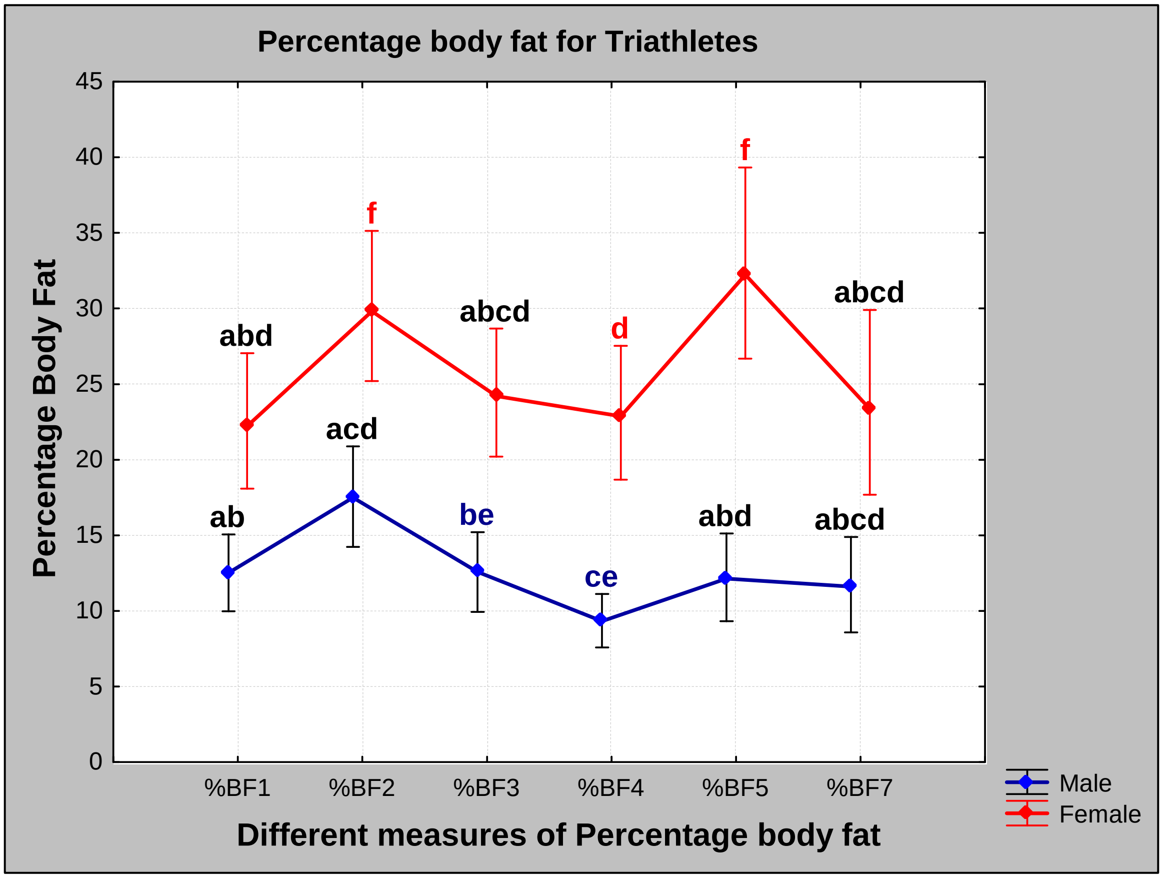

Figure 3.1 Least square means of the different measures of %BF for male and female triathletes. (F (5, 95) = 13.70; p = 0.00). Vertical bars denote 0.95 confidence intervals (CI). %BF 6 was excluded due to the fact that the equation used only applies to males.

Legend:
If %BF1 has an a and a b- all the other methods containing an a or a b had a significant association with %BF1

- %BF1: MF-BIA, Bodystat Quadscan 4000
- %BF2: Durnin and Womersley[149]
- %BF3: Evans et al. 2005 (7 SKF sites)[146]
- %BF4: Evans et al. 2005 (3 SKF sites)[146]
- %BF5: Jackson and Pollock 1985 (4 SKF sites)[147]
- %BF6: Jackson and Pollock 1985 (3 SKF sites MEN ONLY, excluded from this graph)[147]
- %BF7: Body bite Pro nutritional software program[148]

When comparing the measurements (least square means; Figure 3.2), no significant difference was found with the men's results when using analysis of variance and applying the Bonferroni correction between the %BF from the MF-BIA (12.55 (4.19)), %BF from the equation using 7 SKF sites from Evans et al. 2005[146] (12.58 (4.38)) (p = 1.00), the %BF from the 4 SKF site equation from Jackson and Pollock 1985[147] (12.14 (4.93)) (p = 1.00), the %BF from the 3 SKF site equation from Jackson and Pollock 1985[147] (12.52 (4.93)) (p = 1.00) and the %BF from the Body bite nutrition software program[148] (11.69 (5.18)) (p = 1.00). A significant difference was found between %BF measured from MF-BIA and the 4 SKF site equation from Durnin and Womersley[149] (17.51 (5.54)) (p = 0.00001) and the %BF from the 3 SKF site equation from Evans et al. 2005[146] (9.38 (2.96)) (p = 0.01).

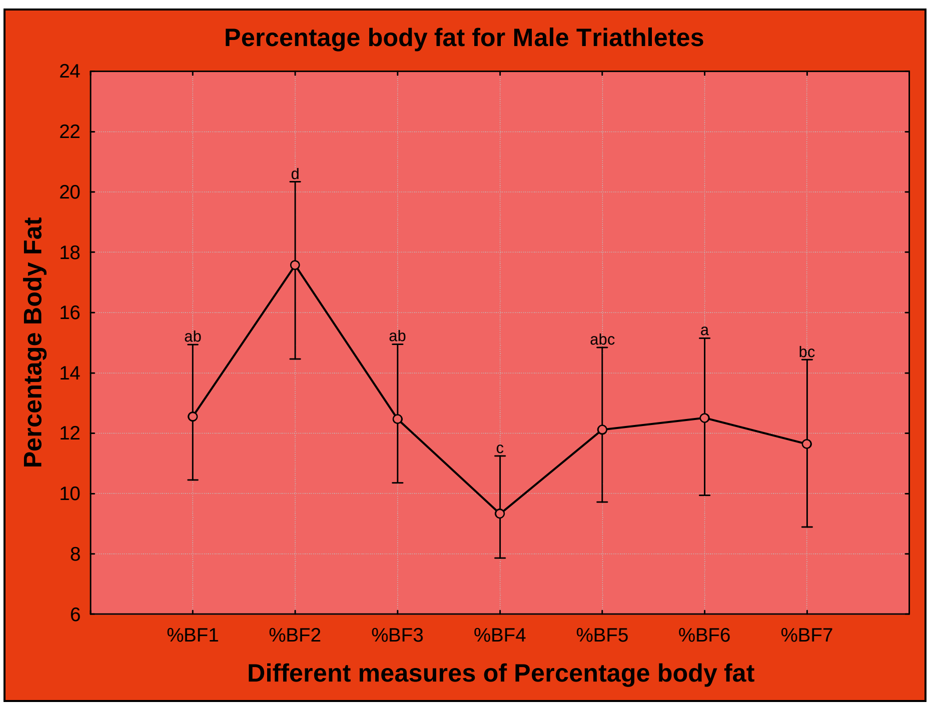

Figure 3.2 Bootstrap means of the different measures of %BF for male triathletes. Vertical bars denote 0.95 confidence intervals (CI).

Legend:
If %BF1 has an ab- all the other methods containing an a or a b had a significant association with %BF1

- %BF1: MF-BIA, Bodystat Quadscan 4000
- %BF2: Durnin and Womersley[149]
- %BF3: Evans et al. 2005 (7 SKF sites)[146]
- %BF4: Evans et al. 2005 (3 SKF sites)[146]
- %BF5: Jackson and Pollock 1985 (4 SKF sites)[147]
- %BF6: Jackson and Pollock 1985 (3 SKF sites MEN ONLY)[147]
- %BF7: Body bite Pro nutritional software program[148]

The %BF from the women's results showed no significant differences (Figure 3.3) in the %BF from MF-BIA (22.32 (6.27)) and the %BF from the 7 SKF site equation from Evans et al. 2005[146] (24.24 (6.13)) ($p = 1.00$), the %BF from the 3 SKF site equation from Evans et al. 2005[146] (22.87 (6.61)) ($p = 1.00$) and the %BF from the Body bite nutrition software program[148] (23.37 (8.95)) ($p = 1.00$). There was however a statistical significant difference between the %BF from MF-BIA and the % BF from the 4 SKF site equation from Durnin and Womersley[149] (29.97 (7.18)) ($p = 0.000000$) and the 4 SKF site equation from Jackson and Pollock 1985[147] (32.40 (8.95)) ($p = 0.000000$).

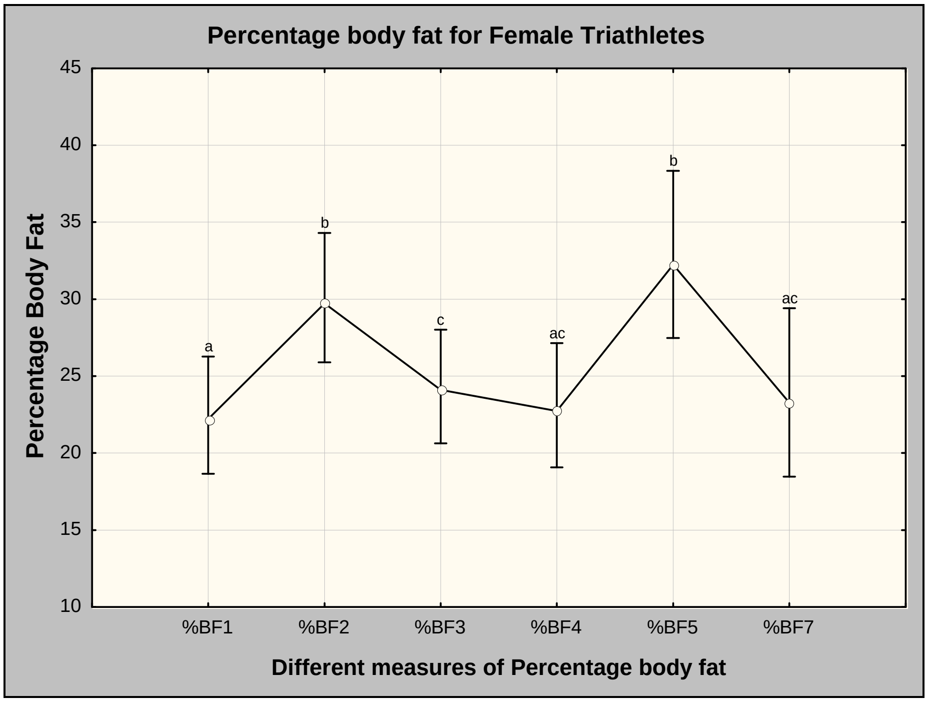

Figure 3.3 Bootstrap means of the different measures of %BF for male triathletes. Vertical bars denote 0.95 confidence intervals (CI).

Legend:
If %BF1 has an a, all the other methods containing an a had a significant association with %BF1

- %BF1: MF-BIA, Bodystat Quadscan 4000
- %BF2: Durnin and Womersley[149]
- %BF3: Evans et al. 2005 (7 SKF sites)[146]
- %BF4: Evans et al. 2005 (3 SKF sites)[146]
- %BF5: Jackson and Pollock 1985 (4 SKF sites)[147]
- %BF6: Jackson and Pollock 1985 (3 SKF sites MEN ONLY, excluded from this graph)[147]
- %BF7: Body bite Pro nutritional software program[148]

3.4 Dietary Macronutrient Intake

The total number of completed food records received were 18 (69%), of which 9 were male and 9 female. Dietary intake from diet (Table 3.4) does not include intake from additional supplements. The total energy intake of the athletes for men and women respectively were 14 534.7kJ (4 509.8) and 9 004.1kJ (368.8). The results from the men and women differed significantly. ($t = 3.3$; $p = 0.05$). The total energy requirement from the MF-BIA was 14 842.5 kJ (1696.7) for men and 10997.7kJ (889.1) for women and differed, as would be expected, significantly (t = 7.0; p = 0.0).

The total carbohydrate intake was 5.3 (1.9) g/kg body weight for the men and 3.5 (0.95) g/kg body weight for the women and differed significantly from each other. (t = 2.4; p = 0.03) Total protein intake was 1.95 (0.5) g/kg body weight for men and 1.2 (0.2) g/kg body weight for the women, which differed significantly. (t = 4.4; p = 0.0004). The total fat intake for men was 34.6% of total energy (10.3) and for women was 29.8% of total energy (6.0) and did not differ significantly from each other. (t = 1.2; p = 0.2). The triathletes had a very good fiber intake, with the mean daily intake for men (26.7g (13.7)) falling within the DRI range and women (22.2g (9.4)) just below the lower range of the DRIs (25-30g/day). (t = 0.8; p = 0.3).

Eighty four percent (*N* = 21) of the triathletes admitted to drinking alcohol in the questionnaire, of which 44% (*N* = 11) were male and 40% (*N* = 10) female. (chi-square; p = 0.32). Nine percent (*N* = 1) and 50% (*N* = 6) for men and women respectively had one drink a day, 64% (*N* = 8) and 30% (*N* = 4) two drinks per day, 9% (*N* = 1) of men three drinks per day and 18% (*N* = 2) and 20% (*N* = 3) (men and women) four drinks per day. One drink is equal to 330ml of beer, 30ml of spirits or 100ml of wine and contains 10g of ethanol.[165] The frequency of alcohol use among men was 9% (*N* = 1) once a week, 9% (*N* = 1) twice a week, 18% (*N* = 2) three times per week, 9% (*N* = 1) four times, 9% (*N* = 1) five times, 9% (*N* = 1) six times and in the majority, 36% (*N* = 4) alcohol seven times per week or daily. The corresponding frequency of alcohol use among women was 20% (*N* =

3) once a week, 10% (*N* = 1) twice a week, 20% (*N* = 3) three times per week, 20% (*N* = 3) four times per week and 60% (*N* = 8) used alcohol seven times per week/daily. The type of alcohol varied widely between beer, cider, wine & spirits.

Table 3.5 Mean (standard deviation) dietary macronutrient intake of the triathletes

Dietary intake	**Male Mean (SD) (*N*= 9)***	**Reference Value**	**Female Mean (SD) (*N* = 9)***	**Reference Value**	**t-test; p value**
Macronutrient intake					
Total energy (kJ)	14534.7 (4509.8)	14842.64 (MF-BIA)	9004.11 (2368.83)	10997.70 (MF-BIA)	t = 3.3; p = 0.01
Total carbohydrate (g/kg body weight)	5.3 (1.9)	6.0-8.0[16]	3.5 (0.95)	6.0-8.0[16]	t = 2.4; p = 0.03
Total protein (g/kg body weight)	1.95 (0.5)	1.2-1.7[39]	1.2 (0.2)	1.2-1.7[39]	t = 4.4; p = 0.0004
Total fat (% total energy)	34.6 (10.3)	25[12]	29.8 (6.0)	25[12]	t = 1.2; p = 0.2
Saturated fatty acids (% total energy)	12.3 (4.1)	10[126]	10.3 (3.2)	10[126]	t = 1.2; p = 0.3
Monounsaturated fatty acids (% total energy)	12.4 (4.7)	10[126]	9.2 (2.9)	10[126]	t = 1.8; p = 0.1
Polyunsaturated fatty acids (% total energy)	6.2 (2.2)	10[126]	6.0 (2.2)	10[126]	t = 0.2; p = 0.9

Table 3.5 Mean (standard deviation) dietary macronutrient intake of the triathletes (continued)

Dietary intake	Male Mean (SD) (*N*= 9)*	Reference Value	Female Mean (SD) (*N* = 9)*	Reference Value	t-test; p value
Macronutrient intake					
Trans fatty acids (g) [% total energy]	2.7 (1.4) [0.7 (0.4)]	< 2% TE[a]	1.6 (1.2) [0.7 (0.5)]	< 2% TE[a]	t = 1.9; p = 0.1
Cholesterol (mg)	437.6 (222.2)	300[166]	271.4 (110.1)	300[166]	t = 2.0; p = 0.1
Total dietary fiber (g)	26.7 (13.7)	25-30[167]	22.2 (9.4)	25-30[167]	t = 0.8; p = 0.4
Alcohol (g) [% total energy]	14.9 (7.3) [2.97 (11.1)]	20-30[b]	2.9 (8.5) [0.95 (2.7)]	10-20[b]	t = 1.9; p = 0.1 [t = 1.6; p = 0.1]

* *N* = 9: Only 9 females and 9 males were included in the analysis of dietary intake due to the fact that only 18 of the 26 subjects returned their completed food record.

[a] < 2% TE: Trans fatty acids should not comprise more than 2% of total energy intake.[166]

[b] 20-30g/d: One alcoholic beverage contains on average 10g of alcohol. The daily recommendations for men are 2-3 drinks per day and for women 1-2 drinks per day. One drink is equal to 30ml spirits, 330ml beer or cider and 100ml wine.[165]

Although the sample size is very small and associations should be interpreted with caution, a tendency was observed between an increased total protein intake of the male and female triathletes correlated well with an increase in lean body mass. (r = 0.5; p = 0.04) (Figure 3.4). The percentage body fat of the triathletes also decreased with an increase in protein intake (Figure 3.5) (r = -0.7; p = 0.004).

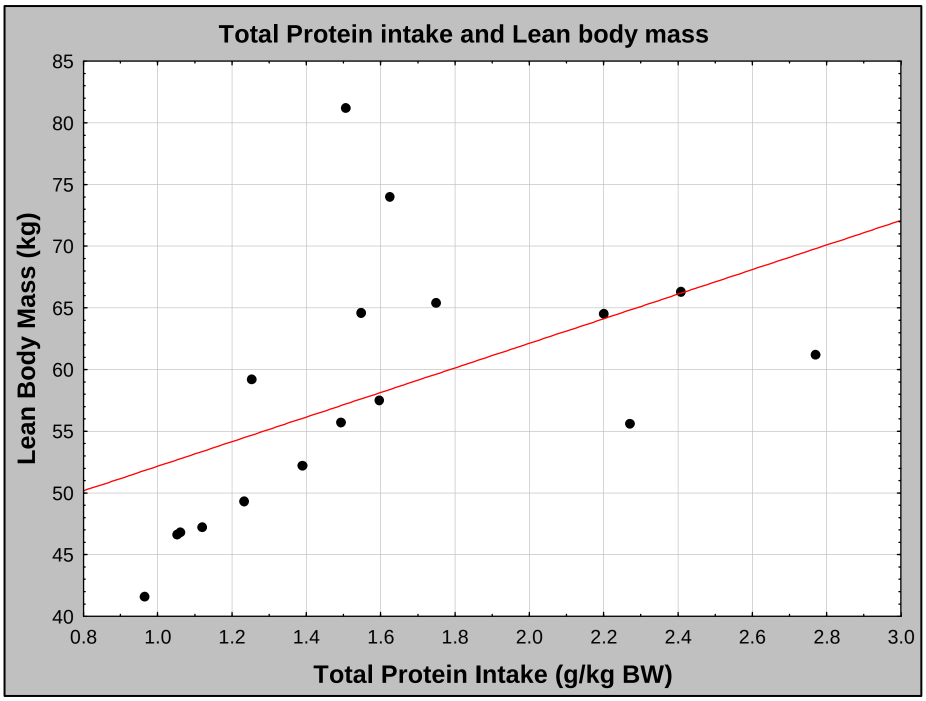

Figure 3.4 Spearman correlation coefficient between total protein intake and lean body mass (r = 0.50; p = 0.04). Eighteen of the triathletes completed the three day food record and MF-BIA measurement was not taken in one subject, therefore *N* = 17

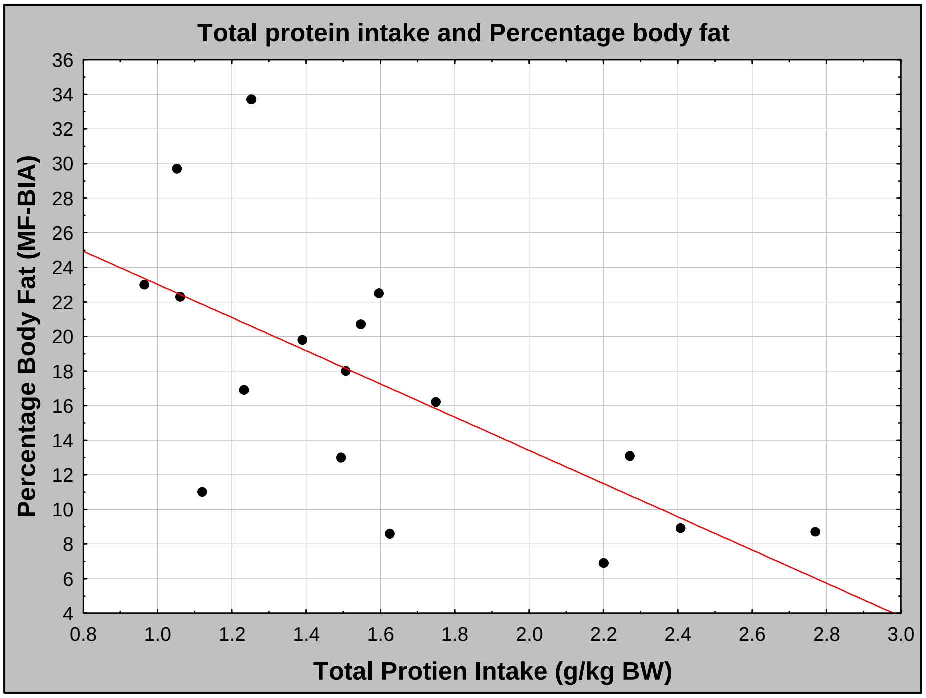

Figure 3.5 Spearman correlation coefficient between total protein intake and percentage body fat from MF-BIA measurement (r = -0.66; p = 0.004). Eighteen of the triathletes completed the three day food record and MF-BIA measurement was not taken in one subject, therefore *N* = 17

3.5 Dietary Micronutrient Intake

The micronutrient intake of the triathletes was evaluated using the Dietary Reference Intakes[167] taking into consideration the increased requirements associated with physical activity level (Table 3.5).[167] This dietary analysis includes the micronutrient intake from the diet alone and not from supplements or the liquid meal replacements (only the macronutrients were added to the food finder analysis). This approach was adopted because it proved impractical to quantify the amounts consumed from the supplements used correctly. The intake of most of the micronutrients (Figure 3.7) fell within 67% - 133% of the DRIs. Due to the limited reference values available for the interpretation of micronutrient intake in groups, the Recommended Daily Allowance (RDA) values were used. Where available the Adequate Intake (AI) and the Estimated Average Requirement (EAR) values were used. The investigators recognized this as a limitation when interpreting the micronutrient intake of the group of triathletes. Most of the micronutrients from dietary intake alone above 133% of the DRI were still below the specified Upper Limit and was not too excessive. The men's intake of sodium, manganese and niacin were above the Upper Limit at 213%, 162% and 228% of the DRI respectively. Only the manganese intake of the women, 174% of the DRIs, fell above the Upper Limit. The micronutrients with an intake below 67% of the DRIs for men included iodine 44%, fluoride 49%. Vitamin C intake of the male triathletes were above (154%) the DRI value and is therefore sufficient. The micronutrients with an intake below 67% of the DRIs for women include chloride 61%, iodine 31% and fluoride 52%. Iron intake of the women is 83% of the DRIs, which is low (although not less than 67%). Vitamin C intake was also sufficient according to the DRIs (218%).

Table 3.6 Mean (standard deviation) dietary micronutrient intake of triathletes by gender

Dietary intake	Male Mean (SD) (*N*= 9)*	DRIs* Reference Value[167]	Female Mean (SD) (*N* = 9)*	DRIs* Reference Value[167]	t-test; p value
Micronutrient intake					
Calcium (mg)	1250.4 (458.2)	1000mg	968.1 (355.2)	1000mg	t = 1.5; p = 0.2
Iron (mg)	21.5 (8.5)	8mg	14.9 (3.6)	18mg	t = 2.1; p = 0.05
Magnesium (mg)	408.7 (175.4)	400mg	333.9 (94.6)	310mg	t = 1.1; p = 0.3
Phosphate (mg)	1998.8 (592.4)	700mg	1376.9 (277.3)	700mg	t = 2.9; p = 0.01
Potassium (mg)	4422.0 (1353.9)	4700mg	3245.4 (759.1)	4700mg	t = 2.3; p = 0.04
Sodium (mg)	3197.0 (270.3)	1500mg	2293.8 (515.9)	1500mg	t = 1.98; p = 0.1
Chloride (mg)	2953.2 (1430.5)	2300mg	1399.2 (447.6)	2300mg	t = 3.1; p = 0.01
Zinc (mg)	17.1 (5.1)	11mg	9.7 (2.1)	8mg	t = 4.0; p = 0.001
Copper (µg)	2030.0 (819.0)	900µg	1533.0 (510.0)	900µg	t = 1.56; p = 0.1

Table 3.6 Mean (standard deviation) dietary micronutrient intake of triathletes by gender (continued)

Dietary intake	Male Mean (SD) (*N*= 9)*	DRIs* Reference Value[167]	Female Mean (SD) (*N* = 9)*	DRIs* Reference Value[167]	t-test; p value
Chromium (µg)	90.2 (29.1)	35µg	57.7 (10.4)	25µg	t = 3.1; p = 0.01
Selenium (µg)	82.3 (53.9)	55µg	58.1 (26.6)	55µg	t = 1.2; p = 0.2
Manganese (mg)	3.72 (2.2)	2.3mg	3.1 (1.0)	1.8mg	t = 0.7; p = 0.5
Iodine (µg)	65.6 (24.3)	150µg	46.8 (10.2)	150µg	t = 2.1; p = 0.1
Boron (µg)	2086.7 (1399.2)	No reference value	1865.7 (1302.3)	No reference value	t = 0.4; p = 0.7
Fluoride (mg)	1.97 (9.9)	4mg	1.6 (5.4)	3mg	t = 1.1; p = 0.3
Silicon (µg)	4474.2 (3759.6)	No reference value	3955.0 (3551.9)	No reference value	t = 0.3; p = 0.8
Vitamin A (µg)	1977.1 (1607.2)	900µg	2093.4 (2285.5)	700µg	t = -0.1; p = 0.9
β-carotene (µg)	5422.6 (6012.98)	No reference value	8721.3 (11826.0)	No reference value	t = -0.8; p = 0.5
Thiamine (mg)	2.3 (0.8)	1.2mg	1.6 (0.6)	1.1mg	t = 2.1; p = 0.1

Table 3.6 Mean (standard deviation) dietary micronutrient intake of triathletes by gender (continued)

Dietary intake	Male Mean (SD) (*N*= 9)*	DRIs* Reference Value[167]	Female Mean (SD) (*N* = 9)*	DRIs* Reference Value[167]	t-test; p value
Riboflavin (mg)	2.6 (0.9)	1.3mg	1.9 (0.8)	1.1mg	t = 1.7; p = 0.1
Niacin (mg)	36.5 (9.8)	16mg	24.2 (8.9)	16mg	t = 2.9; p = 0.01
Vitamin B6 (mg)	2.8 (0.8)	1.3mg	1.9 (0.6)	1.3mg	t = 2.7; p = 0.02
Folate (µg)	329.8 (92.3)	400µg	224.0 (43.3)	400µg	t = 3.1; p = 0.01
Vitamin B12 (µg)	11.2 (8.5)	2.4µg	4.4 (1.2)	2.4µg	t = 2.4; p = 0.03
Pantothenate (mg)	8.96 (2.9)	5mg	6.5 (3.1)	5mg	t = 1.8; p = 0.1
Biotin (µg)	51.1 (20.4)	30µg	40.5 (10.1)	30µg	t = 1.4; p = 0.2
Vitamin C (mg)	138.2 (59.6)	90mg	163.6 (90.2)	75mg	t = -0.7; p = 0.5
Vitamin D (µg)	5.7 (3.2)	5µg	4.4 (1.95)	5µg	t = 1.0; p = 0.3
Vitamin E (mg)	14.5 (6.8)	15mg	11.2 (4.2)	15mg	t = 1.3; p = 0.2

Table 3.6 Mean (standard deviation) dietary micronutrient intake of triathletes by gender (continued)

Dietary intake	Male Mean (SD) (*N*= 9)*	DRIs* Reference Value[167]	Female Mean (SD) (*N* = 9)*	DRIs* Reference Value[167]	t-test; p value
Vitamin K (µg)	264.7 (329.5)	120µg	99.4 (79.7)	90µg	t = 1.5; p = 0.2

***DRIs: Due to the limited reference values available for the interpretation of micronutrient intake in groups, the Recommended Daily Allowance (RDA) values were used. Where available the Adequate Intake (AI) and the Estimated Average Requirement (EAR) values were used.**

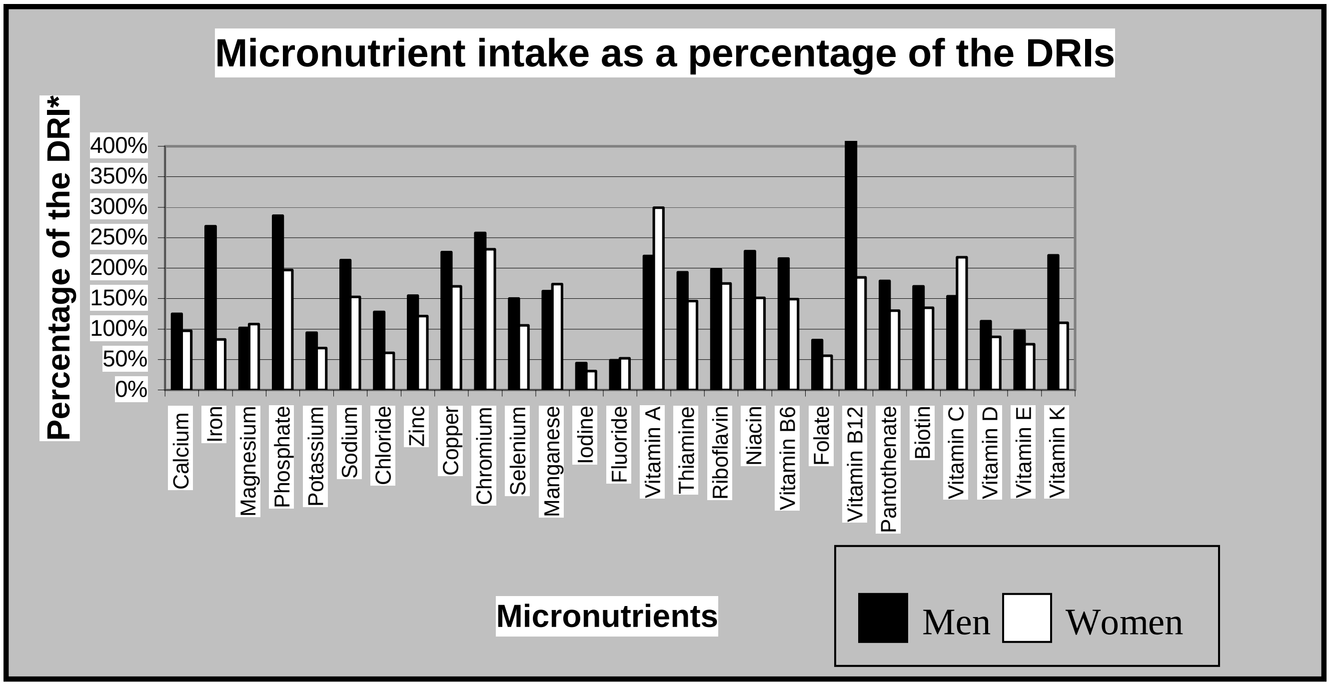

Figure 3.6 Micronutrient intake as a Percentage of the Dietary Reference Intakes

***DRIs: Due to the limited reference values available for the interpretation of micronutrient intake in groups, the Recommended Daily Allowance (RDA) values were used. Where available the Adequate Intake (AI) and the Estimated Average Requirement (EAR) values were used.**

3.6 Dietary Supplements and Ergogenic Aids

Seventy three percent (*N* = 19) of the triathletes used over the counter dietary supplements (chi-square; p = 1.0). Fifty four percent (*N* = 14) of both men and women reported that they used supplements to help them reach their ideal body weight (chi-square; p = 1.0). All the triathletes (*N* = 26) reported that they used either one or more forms of protein supplements (100%). This included protein bars (81%) (chi-square; p = 0.6) (*N* = 21); protein powders (58%) (chi-square; p = 0.2) (*N* = 15) and high protein powders (15%) (chi-square; p = 0.3) (*N* = 4). Twenty seven percent of the triathletes used single amino acids (chi-square; p = 0.7) (*N* = 7). The majority (81%) used a form of carbohydrate supplement (chi-square; p = 0.1) (*N* = 21). This included carbohydrate electrolyte solutions (35%) (chi-square; p = 0.7) (*N* = 9), carbohydrate gels (19%) (chi-squared; p = 0.1) (*N* = 5), carbohydrate bars (15%) (chi-squared; p = 0.3) (*N* = 4) and **high** carbohydrate drinks (12%) (chi-square; p = 0.5) (*N* = 3). Other popular supplements used among the triathletes were multi-vitamin and mineral preparations (81%) (chi-square; p = 0.6) (*N* = 21) and antioxidant supplements (including glutamine) (62%) (chi-square; p = 0.4) (*N* = 16) (Table 3.6).

Most of the athletes took supplements daily (35%) (*N* = 9), several times a week (19%) (*N* = 5) or during specific times, i.e. increased training or racing on consecutive weekends (19%) (*N* = 5). The others took the supplements either occasionally (12%) (*N* = 3) or once a week (15%) (*N* = 4).

The most popular reasons given by the triathletes for using supplements, were recovery (62%) (*N* = 16), increased energy supply (61%) (*N* = 16), enhanced immune function (50%) (*N* = 13), increased muscle mass (54%) (*N* = 14) performance enhancement (46%) (*N* = 12) and insufficient dietary intake (31%) (*N* = 8) (Figure 3.8).

Table 3.7 Prevalence of supplement use among the triathletes

Supplement category:	Supplements	Percentage of triathletes (*N* = 26)	Chi-square; p-value
Increased muscle growth and repair	Protein	100% (*N* = 26)	No value
	Amino acids	27% (*N* = 7)	p = 0.7
Increased energy supply	Carbohydrate	81% (*N* = 21)	p = 0.1
	Creatine	12% (*N* = 3)	p = 0.5

Table 3.7 Prevalence of supplement use among the triathletes

Supplement category:	Supplements	Percentage of triathletes (*N* = 26)	Chi-square; p-value
Increased immune function	Antioxidants	54% (*N* = 14)	p = 1.0
	Glutamine	4% (*N* = 1)	p = 0.3
Increased joint health	Glucosamine sulphate	4% (*N* = 1)	p = 0.3
CNS stimulants	Caffeine	4% (*N* = 1)	p = 0.3
Fat reduction	Carnitine	4% (*N* = 1)	p = 0.3
Electrolytes	Salt tablets	19% (*N* = 5)	p = 0.6
General health	Multi-vitamin and mineral	81% (*N* = 21)	p = 0.6
	Vitamin B12	65% (*N* = 17)	p = 0.7
	Single Minerals	58% (*N* = 15)	p = 0.7
	Iron	4% (*N* = 1)	p = 0.3
	Calcium	4% (*N* = 1)	p = 0.3
	Magnesium	27% (*N* = 7)	p = 0.2
	Essential fatty acids	8% (*N* = 2)	p = 1.0
	Herbal supplements*	42% (*N* = 11)	p = 0.7
	Probiotics	4% (*N* = 1)	p = 0.3

*Herbal supplements include ginseng, Echinacea, inositol, guarana and green tea extract.

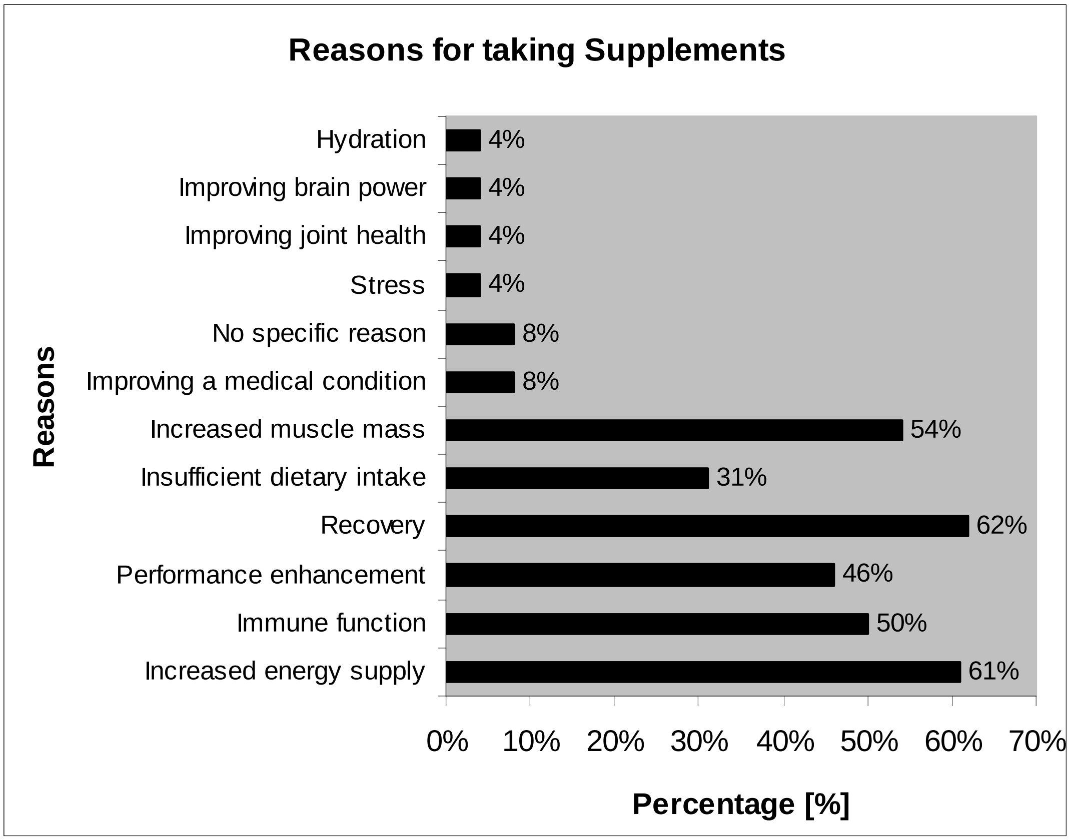

Figure 3.7 Reasons given by the triathletes for taking supplements

3.7 Clinical Health Status

None of the men or women reported unwanted weight loss in the past 6 months. Eight percent (*N* = 2) of the women reported to have had unwanted weight gain, whilst none of the men reported unwanted weight gain (chi-square; p = 0.2). Four percent (*N* = 1) of the women and none of the men felt fatigued all the time (chi-square; p = 0.3). Twenty percent (*N* = 5) of the triathletes experienced an increase in appetite in the preceding 6 months (chi-square; p = 0.2). Twenty percent (*N* = 5) of the triathletes reported suffering from gastro-intestinal problems (chi-square; p = 0.6), including being previously diagnosed with irritable bowel syndrome (12%) (chi-square; $p = 0.1$) ($N = 3$) and flatulence (8%) (chi-square; $p = 0.2$) ($N = 2$)

One of the objectives of the study was to determine whether the dietary intake or body composition had an influence on the general health status. Due to the limited sample size associations only indicate a tendency and should be interpreted in lieu of the small sample size.

The triathletes reported symptoms related to respiratory tract allergic responses and exercise induced asthma. (Figure 3.9). Twelve percent ($N = 3$) reported feeling chest tightness, 8% ($N = 2$) suffered from wheezing, 27% ($N = 7$) had itchy eyes, 27% ($N = 7$) had itching of the nose or throat with sneezing spells, 12% ($N = 3$) reported that they suffer from chest tightness, together with cough, wheezing and shortness of breath during running sessions. Twelve percent ($N = 3$) said that these symptoms affected them whilst training and that they had missed training sessions or under performed due to these symptoms. However none of the respondents reported missing work or classes due to these symptoms. Eight percent ($N = 2$) had trouble breathing or cough during or after exercise, 42% ($N = 11$) had become dizzy during or after exercise, 4% ($N = 1$) had fainted or passed out during exercise, 4% ($N = 1$) experienced chest pain during exercise, 19% ($N = 5$) experienced heart racing or skipping of heart beats during exercise. Four percent ($N = 1$) found that they got tired more quickly than their peers during exercise, and 4% ($N = 1$) have had or did have a diagnosed lung disease.

When comparing the prevalence of chest tightness to the total energy intake, a positive association was found with the Mann-Whitney test ($p = 0.05$) (Figure 3.10). When comparing the prevalence of chest tightness together with coughing, wheezing and shortness of breath during exercise to the total energy intake, a positive association was found with the Mann-Whitney test ($p = 0.05$) (Figure 3.11). A positive association (Mann-Whitney; $p = 0.02$) was also found between the total carbohydrate intake and the prevalence of chest tightness together with coughing, wheezing and shortness of breath during exercise as well as between a decreased carbohydrate intake and an increased prevalence of feeling dizzy during or after exercise. (Mann-Whitney; $p = 0.05$) (Figures 3.12 – 3.13)

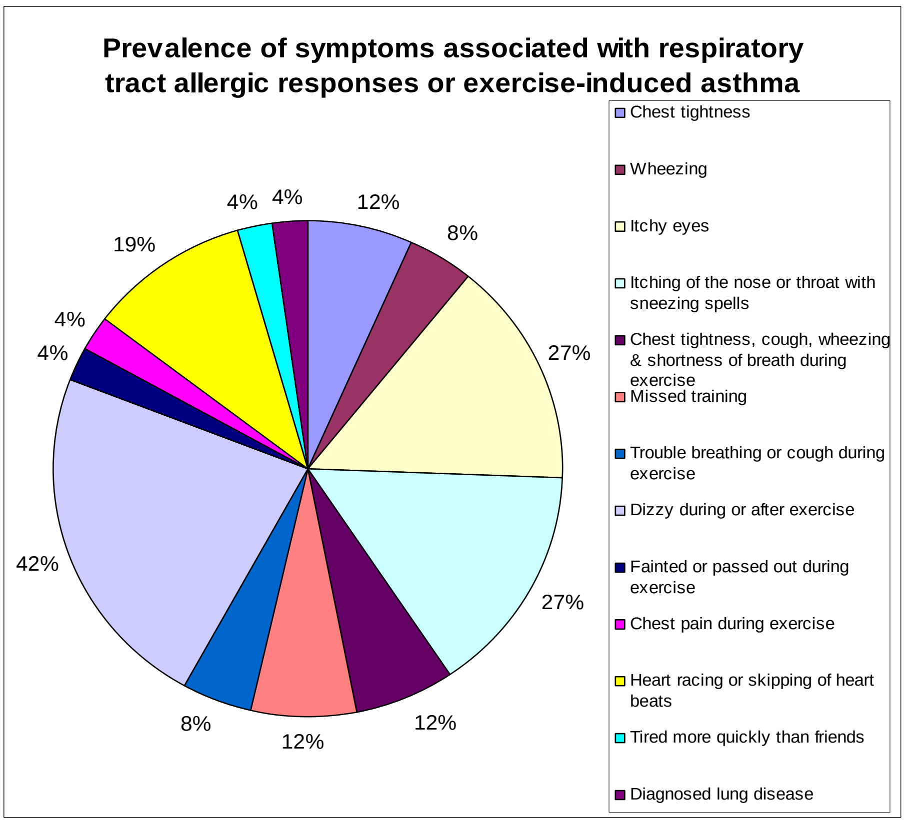

Figure 3.8 Prevalence of symptoms associated with respiratory tract allergic responses or exercise-induced asthma.

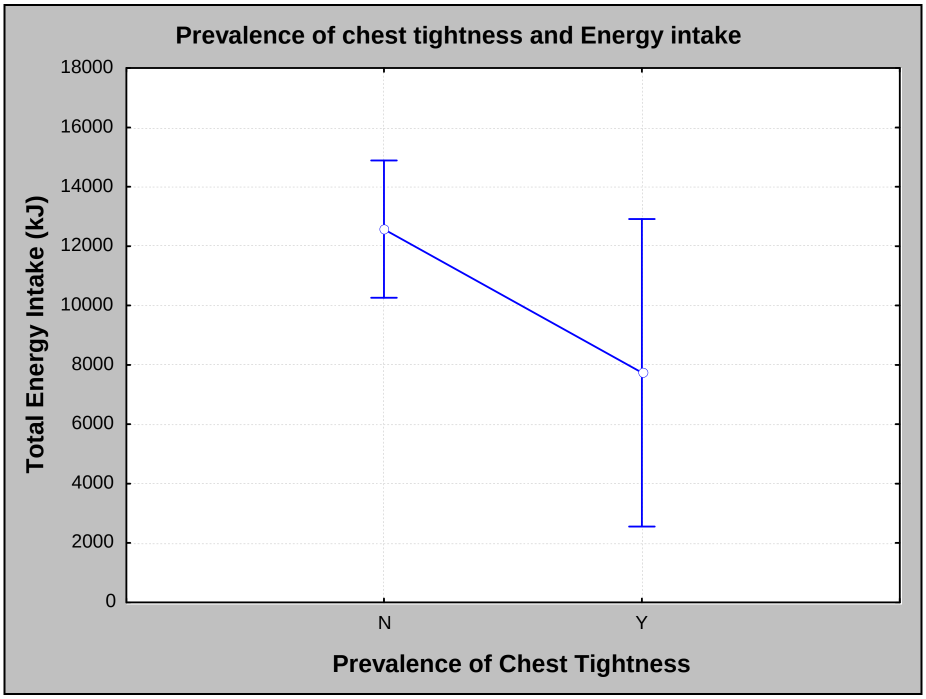

Figure 3.9 Increased prevalence of chest tightness with a lower energy intake (p = 0.05). Vertical bars denote a 0.95 confidence interval.

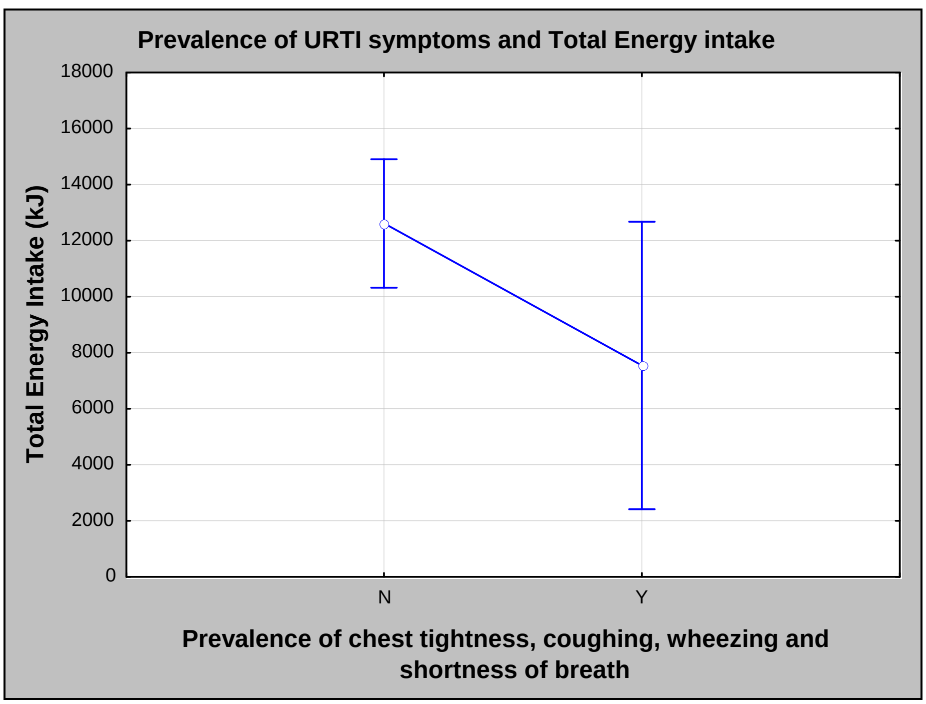

Figure 3.10 Increased prevalence of chest tightness, coughing, wheezing and shortness of breath during exercise with a lower energy intake (p = 0.05). Vertical bars denote a 0.95 confidence interval.

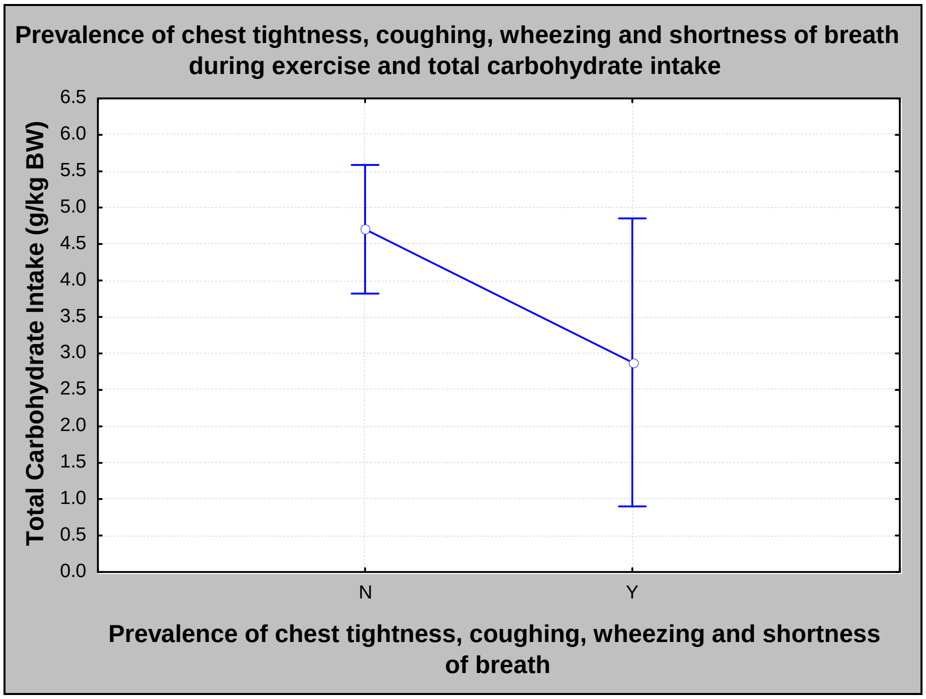

Figure 3.11 Increased prevalence of chest tightness, coughing, wheezing and shortness of breath during exercise with a lower carbohydrate intake (p = 0.02). Vertical bars denote a 0.95 confidence interval.

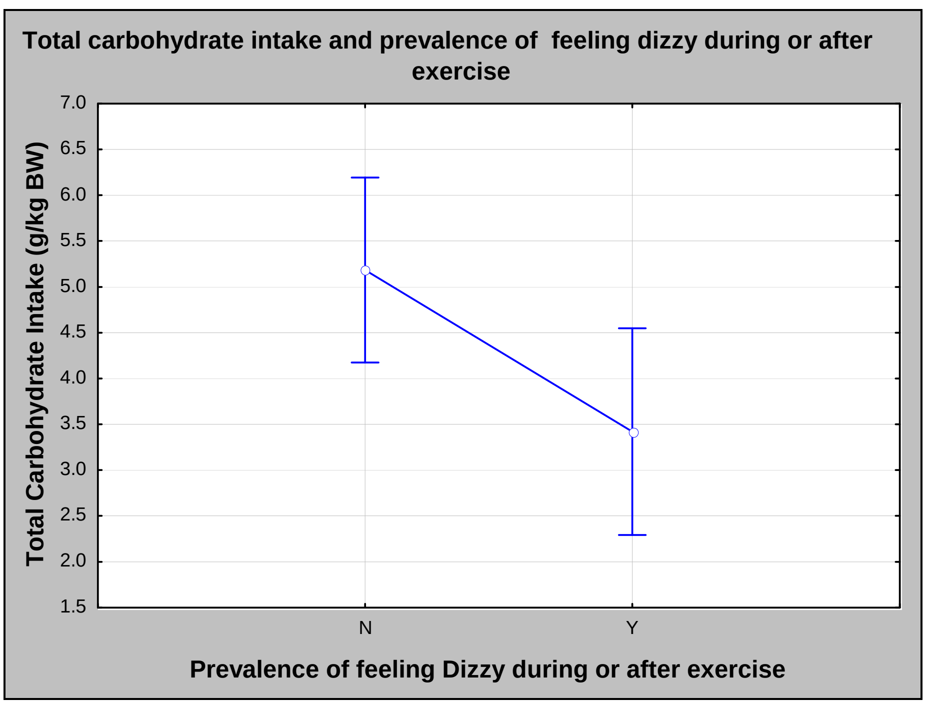

Figure 3.12 Total carbohydrate intake and the prevalence of feeling dizzy during or after exercise. (p = 0.05). Vertical bars denote 0.95 confidence intervals.

Fifteen percent (*N* = 4) of the triathletes suffered from frequent or severe headaches and 38% (*N* = 10) suffered from numbness or tingling in their arms, hands, legs and feet. Thirty eight percent (*N* = 10) suffered from frequent or severe back pain. Thirty five percent (*N* = 9) reported feeling stressed out or suffered from anxiety. Fifteen percent (*N* = 4) reported getting ill from exercising in the heat, but only 4% (*N* = 1) reported passing out from exercising in the heat. Fifty eight percent (*N* = 15) of the triathletes had experienced muscle cramps. Fifteen percent (*N* = 4) had a high cholesterol level and twelve percent (*N* = 3) have high blood pressure. Eight percent (*N* = 2) of women reported that they had previously been diagnosed with iron deficiency anemia.

An increasing awareness of the female athlete triad in women led to questions regarding menstrual cycle, anxiety and stress fractures. Sixty nine percent (*N* = 9) of the women reported to have had a broken bone in their body, 15% (*N* = 2) had a shoulder injury, 46% (*N* = 6) suffered from severe and frequent back pain, 31% (*N* = 4) suffered from stress or anxiety, 38% (*N* = 5) suffered with chronic knee injuries related to cartilage damage and 8% (*N* = 1) have had an ankle sprain.

All the women started their menses between the ages of 11-15 years with the most starting their menses at 14 years of age (36%) (*N* = 5). Seventy three percent (*N* = 10) of the women reported having had a menstrual period the last month, 9% (*N* = 1) had their last menstrual period more than a year ago, 9% (*N* = 1) 2 years ago and 9% (*N* = 1) 5 years ago. Ninety percent (*N* =) of the women who still experience their menstrual period said the longest time between two periods is usually 20-30 days, whilst only 10% (*N* = 1) reported 80-90days. Fifty percent (*N* = 7) of the women had 12 periods in the last year, 38% (*N* = 5) had 5 periods and 12% (*N* = 1) only had 3 periods in the past year. Sixty percent (*N* = 8) of the women reported taking an oral contraceptive daily and altering their menstrual cycle to suit training/racing requirements. Twenty percent (*N* = 3) of the women reported taking specific medication to stop them from menstruating for extended periods of time in order to train or race with more comfort.

CHAPTER 4: DISCUSSION

This is the first study of its type in South Africa using triathletes as study population. The findings of this study contribute to the body of current knowledge on endurance athletes like runners and cyclists, but gives new insight on the nutritional status of triathletes. Inconsistent information regarding reference values for body composition and dietary intake exist for triathletes specifically and it is not the ideal to extrapolate research findings on endurance runners, cyclists or swimmers to the triathlon population.

The sport of triathlon encompasses three disciplines; swimming, cycling and running. To participate in this sport one needs to have the commitment and self discipline to achieve your goals. It is a specialist sport and requires dedication. The field of sport nutrition involves athlete's anthropometry or body composition, clinical assessment of their medical health status, dietary intake and supplement use.

The key findings of the present study were that percentage body fat calculated from skinfold prediction equations generally correlated well with percentage body fat measured with MF-BIA. The percentage body fat of the men and women were at the upper end of the range associated with elite athletes and related more to the percentage body fat of amateur athletes.[168] The athletes had a good dietary intake of micronutrients. Our findings were that the triathletes consume less than optimal amounts of dietary carbohydrate, which can be attenuated by the vast majority of the triathletes taking additional carbohydrate supplementation. Supplements were used widely among the athletes, including protein supplementation even though dietary protein intake was adequate for both men and women. Fat intake was higher than the recommendation in both groups. Almost half of the study group also reported taking herbal supplements.

4.1 Anthropometry vs. MF-BIA measurements

In the present study, significant associations in both and men women were obtained between percentage body fat calculated from skinfold measurements and MF-BIA. The findings of this study support those described by Ostojic et al. 2005[151] who found that %BF from skinfold measurements and %BF from BIA correlated well in 219 professional male athletes.[151] They concluded that BIA is less time consuming, quick and easy to determine %BF in athletes.[151]

The reason behind measuring skinfold measurements is the assumption that subcutaneous fat is proportional to total body fat. This however is an assumption that is made and will definitely differ between individuals.[169] The different equations used to determine %BF will definitely yield different results as any differences in the fat tissue distribution from the original equation used will result in error.[170] According to the literature, the different regression equations used can give a 3-4% difference in the %BF obtained.[170]

Bio-electrical impedance analysis is also gaining popularity within the field of athletics due to its ease of administration and its comparability to skinfold measurements of %BF. It is said that when care is taken with measuring MF-BIA and skinfold measurements, the %BF should not differ with more than 3-4%.[170] In this study we found associations between MF-BIA and some of the regression equations used to determine %BF from skinfold measurements. There are over 100 different equations to predict %BF from skinfold measurements. In this study, the equations using skinfold measurements from the thigh as well as measurements from the upper body in men correlated well with MF-BIA. Ostojic et al. 2005[151] also found a significant association between BIA and 7 SKF measurements. In the present study, the 7 SKF equation from Evans et al. 2005[146] using subscapular, tricep, chest, mid-axillary, supra-iliac, abdominal and thigh skinfolds, the 4 SKF equation from Jackson and Pollock 1985[147] using the abdominal, suprailiac, thigh and tricep skinfolds and the 3 SKF equation from the Body bite nutrition software program[148] using the chest, abdominal and thigh skinfolds in men correlated best with the MF-BIA. The Durnin and Womersley[149] equation using body density to determine %BF did not correlate with the %BF of the MF-BIA and gave a much higher %BF. A reason for this might be that it only takes skinfolds from the upper body into consideration, i.e. sub-scapular, suprailiac, tricep and bicep skinfolds and not the lower extremities. The 3 SKF equation from Evans et al. 2005[146] using the mid-axillary, thigh and calf equation also showed a poor association with the MF-BIA as this takes more of the lower extremities into consideration and not SKF from the abdominal region.

Sport nutrition for professional athletes rank the male elite or endurance athlete's %BF as being optimal in the range of 5-9%[168] while Norms for physical fitness described the %BF of male swimmers to be 15.1%.[170] This might explain the big difference in %BF when comparing measurements using skinfold sites from the upper body or the lower body or both. It is clear from these results and the two most significant outliers (Durnin and Womersley[149] and 3 SKF equation from Evans et al. 2005)[146] that equations used to calculate the %BF in MEN using more of the skinfold sites from the upper body tend to give a higher %BF in comparison to MF-BIA and equations using more of the skinfold sites from the lower extremities tend to give a lower %BF in comparison to MF-BIA. This might in part give an explanation why there are two different types of triathletes; you often find the strong swimmers are not as good runners and vice versa. If swimmers have a higher %BF as mentioned previously, they have to use more muscular effort to transport the extra adipose tissue during the run.[171] This is confirmed by Alejandro et al. 2006[171] who found that the lower skinfold measurements from the lower body extremities showed a positive association with running performance.[171]

Women's %BF also varies according to the type of sport, a %BF of 18.3% in distance running females and %BF of female swimmers to be 23.5% have been described.[170]

In the present study, the results from the skinfold prediction equations differed only with the one method from the men's results. The Women's results indicated a good association between MF-BIA and %BF from the equations using 3 SKF from Evans et al. 2005[146] and the value obtained from the body bite nutrition software program[148], which also uses 3 SKF. The 3 SKF equation from Evans et al. 2005[146] used SKF measurements form the midaxilla, calf and thigh, while the nutrition software program used SKF measurements from the tricep, supra-iliac and thigh skinfold sites. The equation using 7 SKF from Evans et al. 2005[146], also correlated well with MF-BIA. The one outlier in the women's results agreed with the men's results. This outlier was the equation from Durnin & Womersley[149] and again gave a significantly higher value. The other outlier was the equation from Jackson and Pollock 1985[147] using 4 SKF sites, abdomen, supra-ileac, tricep and thigh. The inappropriateness of the equation by Durnin and Womersley[149] for athletes is confirmed by Stewart et al. 2001[169] who reported that this equation was singled out in a study as "overestimating fat excessively" and as being "inappropriate for athletes".[169]

The difference in the percentage body fat values can be ascribed to fat patterning, which is not only influenced by age, race and gender, but by the type of training as well. Swimming, cycling and running will all induce different body morphisms. Although we are describing a triathlete as a whole, the individual differences and preference of training will influence fat patterning.

It should also be noted that no amount of preparation would exclude all source of error when performing skinfold measurements and BIA. Inter –and intra-subject variability, subjects not complying with pre-test conditions as well as error on the investigator's part can influence measurements, although all care was taken to limit these errors. It should also be noted that chronic training induces changes in body composition and the question should not necessarily be how much total body fat the athlete has, but which skinfold site influence performance as explained by Alejandro et al. 2006[169,171]

4.2 Ideal Body Weight and Percentage Body Fat

Triathletes tend to always want to fall within the lower ranges of the ideal body weight range. The women in the present study had a mean body weight of 64kg and the men a mean body weight of 79kg. When determining their ideal body weight range according to the World Health Organizations recommendations of the normal BMI range (18.5-24.9kg/m^2) we find an ideal range of 53 – 71kg for women and 59-80kg for men.[159] Both these ranges are very wide. The men and women therefore fall within the normal range, but they do not tend to go toward the lower end, especially the men. According to the book Norms for fitness performance and health[170], the average weight of adult females aged 20-74 years is 71.1-74.9kg, which is well above our study population and the average weight for males aged 20-74 years is 83.4-87.1kg, which is also higher than the mean of our study population.[170] This illustrates the point that the body mass index is not an accurate indicator of ideal body weight in athletes as it can easily classify a very muscular person as being overweight, in our case, especially the men. This led to an increased reliance on measuring body composition in athletes to determine their optimal racing physique.

According to Hellemans[164] the ideal %BF for male triathletes is 6-10% and 11-18% for female triathletes, however, Worme et al. 1990[172] did a study on 21 female and 50 male recreational triathletes and found the %BF to be 15% and 24% for men and women respectively.[172] The latter agrees with the present findings of a %BF of 13% for men and 21% for women. A study done on 8 female and 10 male athletes competing in the Ironman triathlon in New Zealand found their %BF to be and 15% and 22% for men and women respectively.[173] According to the American Dietetic Association endurance athletes, including triathletes should strive toward achieving optimal body fat percentage in the region of 6-19%.[12] Females tend to be at the upper end of the range and males at the lower end. Sport nutrition for professional athletes classify a range of 15-18% for women as fat levels found in elite athletes, where a range of 19-22% is classified as being excellent for health and longevity.[168] Men with a %BF of 5-9% are the levels found in elite athletes and between 10-15% excellent for health and longevity.[168] It is clear from our study results that the study group does not fall into the elite category, but in the amateur category. The difference in %BF from the various sources differs due to the fact that some are general recommendations for endurance athletes and some are specifically for triathletes. The difference in the reference values for elite and amateur athletes are due to differences in training amount and intensity. The type of triathlon racing, i.e. olympic distance triathlon vs. ironman triathlon also requires different body composition values.

The next leg of determining the nutritional status of triathletes is the dietary intake, which directly influences their body composition and performance.

4.3 Energy Intake

An athlete's habitual dietary intake is very important to ensure that he or she meets the increased energy requirements and it needs to promote long-term health. The body's ability to adapt to the stress of intense daily exercise depends on the adequacy of the athlete's diet.[174] Sub-optimal macro –and micronutrient intake can lead to a severe decrease in performance. It is important for athletes to reach their optimal body composition and maintain this throughout their athletic career.

The total energy requirement for the triathletes as determined by the MF-BIA in the present study was 14 842kJ for men and 10998kJ for women and the intake of the men were 14 535kJ and the women to be 9 004kJ. The MF-BIA uses the Brozek and Grande formula for determination of basal metabolic rate and is based on the measured lean body mass in contrast to other formulas like the Harris –Benedict equation which is based on total body weight. It is known that this equation can overestimate the basal metabolic rate with 10%.[155] The men therefore had an adequate total energy intake, but the women were found to be in a slightly negative energy balance. The WHO defines energy requirement as "the level of E intake from food that will balance energy expenditure when the individual has a body size and composition, and level of physical activity, consistent with long-term good health; and that will allow for the maintenance of economically necessary and socially desirable physical activity."[159]

The women did however have a normal percentage body fat and BMI and none of the women reported weight loss in the preceding months and only the minority reported symptoms of fatigue, which indicates that the women are indeed in energy balance. The women's results coincided with findings of Worme et al. 1990[172] who found the mean total energy intake of 21 recreational female triathletes to be 9058kJ. However, they reported the mean total energy intake for 50 male triathletes to be 11 591kJ.[172] The present findings however were significantly lower than data reported by Burke 2001[175] on the dietary intake of cyclists during training also keeping a 3 day food record. Burke 2001[175] found in 6 male Irish Olympic team cyclists an energy intake of 16 300kJ and 16 2000kJ per day on 2 occasions respectively.[175] Data from 18 US national and collegiate level cyclists showed an energy intake of 17 320kJ per day and data from the 9 cyclists on the German national team had an intake of 26 500kJ per day.[175] Although this is all elite cyclists, our study group also included elite triathletes with the highest energy intake among the men reaching 21 801kJ. The women tended to have a lower energy intake and Burke 2001[175] demonstrated that the intake of 12 US national and collegiate level cyclists also keeping a 3day food record had an energy intake of 12 660kJ, which is significantly higher than our group. Athletes can only sustain a very high level of exercise if they maintain energy balance. Edwards et al. 1993[14] reported values for energy intake of male triathletes were 19 100kJ and for female runners a mean value of 8 527kJ.[14] Frentsos et al. 1997[176] completed a study on 6 elite triathletes and also concluded that they did not meet their daily energy, carbohydrate, zinc and chromium requirements.[176]

Energy balance is only reached when there sufficient carbohydrate, protein and fat are ingested to balance out the energy expended during a physical activity session and is of vital importance for performance.

4.4 Carbohydrate Intake

Carbohydrate intake of 21 female and 50 male recreational triathletes as reported by Worme et al.1990[172] were 5.1g/kg body weight and 4.9g/kg body weight for men and women respectively.[172] Carbohydrate intake from a 3 day food record of the cyclists in the review by Burke 2001[175] ranged from 7.3-10.9g/kg BW for men and 5.4g/kg for the women.[175] Nogueira et al.[17] also described the CHO intake of endurance athletes as 4.5-11.3g/kg BW for males and 4.4-7.2g/kg BW for females with a gradual decrease in performance.[17] Frentsos et al. 1997[176] also reported that 6 elite triathletes only had a carbohydrate intake of 4g/kg BW before intervention.[176] The triathletes in the present study are not meeting carbohydrate requirements with an intake of 5.26g/kg BW for men and 3.54g/kg BW for women. Recommendations to increase the carbohydrate intake to 7-9g/kg BW should be made. The choice of carbohydrate the athletes made was more complex than refined carbohydrates as the fiber intake of the triathletes were adequate. The habitual carbohydrate intake does not take into account additional sugar from glucose or glucose polymers in sports drinks and gels even though the majority of the triathletes used some form of carbohydrate supplementation during the various training phases. It can be concluded that with supplementation the triathletes may be achieving their CHO requirements It should also be noted that during times of intense training or before a race or training session, high fiber carbohydrates can aggravate gastro-intestinal symptoms like irritable bowel syndrome and flatulence reported by the study population and care should be taken to ensure personal preference and tolerance.[20,21,26]

Muscle glycogen is the most important energy substrate during endurance exercise (Figure 4.1) and a decreased intake can lead to less than optimal training, recovery post training and performance.

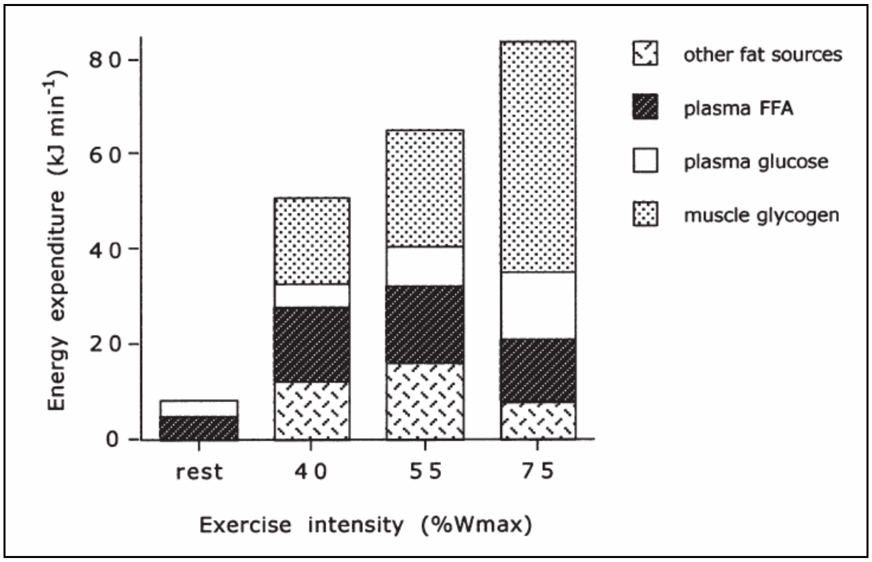

Figure 4.1 Substrate utilization during exercise
Source: Van Loon et al. 2002[177]

When athletes are not meeting their carbohydrate requirements, they are also at an increased risk for developing upper respiratory tract infections (URTI).[178] Nieman et al.1998[178] indicated the relationship between exercise intensity and the risk for URTI (Figure 4.2)

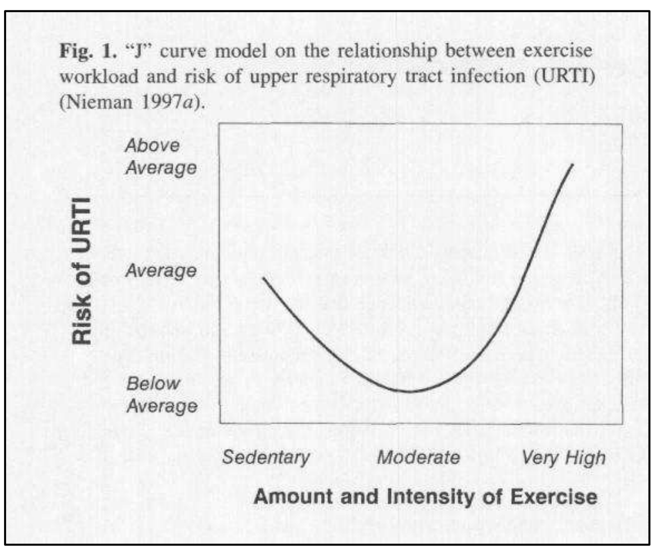

Figure 4.2 The relationship between exercise intensity and the risk for developing URTI
Source: Nieman et al. 1998[178]

When an athlete trains with a sub-optimal CHO intake during exercise there are greater increases in the circulating stress hormones which can lead to a degree of immunosuppression.[179] A sub-optimal carbohydrate intake can lead to feeling fatigue, often not being able to finish training sessions due to a feeling of hitting the wall, lack of energy, heavy legs, slow rate of recovery, and loss of concentration, dizziness, irritability and fainting.[25,26] Reduced CHO intakes have also been linked to the increased prevalence of URTI due to a decreased immune competence.[179]

The prevalence of dizziness during exercise among the study group was 42% and there were a significant association between the low carbohydrate intake and the dizziness experienced by the triathletes. The low CHO intake of the women might be a reason why some of them experienced fatigue and why 35% of the total population felt stressed out. An association cannot however be drawn due to the confounding effect of additional carbohydrate supplementation and due to the fact that they were not in a negative energy balance. A significant association was found between an increased prevalence of respiratory tract allergic responses or exercise-induced asthma and a low CHO intake.

Increased CHO intake can be recommended in this group and can be achieved by altering their meal patterns during the day, including more CHO rich snacks and by adjusting their specific training diets to include the specific amount of CHO before, during and after training sessions and all effort should thus be made to ensure that the athletes reach their carbohydrate requirements, not only to enhance their performance, but to maintain a healthy immune function too.

4.5 Protein Intake

The protein intake of the men was found to be higher than the recommended amount, although still under the maximum allowance of 2g/kg/day.[39] The present study indicated that the dietary intake alone of protein for male triathletes were 1.95g/kg BW and the female triathletes 1.20g/kg BW and all the triathletes reported taking some form of protein supplement. Our findings agree with the habitual protein intake of athletes as confirmed by Burke 2001[175] who reported male cyclists to have a protein intake of 2.0-2.6g/kg per day and the female cyclists to have an intake of 1.3g/kg per day.[175] Worme et al.[172] reported the habitual protein intake of both male and female triathletes to be 1.4g/kg body weight per day.[172] Nogueira et al.[17] reported a habitual dietary protein intake for endurance athletes as 1.2-2.0g/kg body weight.[17] The athletes should not supplement with extra protein as the increased energy demand of their physical activity also leads to a higher habitual protein intake, especially the male triathletes. A very high protein intake, beyond 2g/kg body weight, not only has no beneficial effect for the athlete[39], it can have negative side effects, including constipation, an increased fat intake, increased calcium excretion and increasing their protein intake at a cost of their CHO intake, which is not desirable. Women have a lower energy intake and therefore their habitual protein intake is also at the lower range. Women also tend to restrict dietary intake to reach their ideal weight and therefore compromise total energy intake. A tendency was seen in the present study's results with an increased protein intake correlating with an increase in lean body mass and decreased body fat, which in turn increases the basal metabolic rate. Norgan 2005[180] demonstrated that body composition is widely used as a tool to standardize other variables. He indicated that lean body mass or fat free mass is the "single best estimator of basal metabolic rate with age and sex adding only small contributions". Our findings agree with Norgan 2005[180] as we found an association between an increased lean body mass and increased basal metabolic rate as determined by MF-BIA.

Vegetarians and athletes with eating disorders are at risk for inadequate dietary protein intake. Protein in an endurance athletes' diet is especially important for recovery after training sessions. Protein is required to cover the increased losses of amino acids oxidized during exercise and to provide extra raw material to replace exercise induced muscle damage.[41] Protein intake has directly been linked to lean body mass in previous studies as it helps with muscle protein synthesis in resistance or strength training athletes.[180] A further increase in lean body mass when protein intake is increased beyond 2g/kg body weight did not lead to an increased lean body mass in resistance training athletes.[39]

4.6 Fat Intake

Fat is a very important macronutrient for endurance athletes. Although recent literature states there is no place for fat loading in the diet and training regime of endurance or ultra-endurance athletes,[38] it still provides the training diet with essential fatty acids and fat soluble vitamins. The male and female triathletes in this study had a very high fat intake compared to the requirements of 25% of total energy intake. The distribution of the different types of fatty acids in this group was not according to prudent dietary guidelines, with poly-unsaturated fatty acids at 6.23% of total energy intake, mono-unsaturated fatty acids at 12.37% of total energy intake and saturated fatty acids at 12.33% of total energy intake. The inclusion of more essential fatty acids will aid in bone health and brain power, listed as reasons why the triathletes take supplements and the decrease in the intake of saturated fat will reduce the prevalence of high cholesterol levels. 8% of the triathletes reported taking an essential fatty acid supplement.

4.7 Dietary Micronutrient Intake

There are certain vitamin and mineral requirements that are increased during physical activity. Vitamins and minerals involved in energy metabolism are vitamin B1, vitamin B2, vitamin B3, magnesium, zinc, copper and chromium.[55,56,57,58,59,60] Vitamins and minerals involved in blood cell coagulation are iron, vitamin B12 and vitamin K and antioxidants required to support immune function include beta-carotene, vitamin C, vitamin E and selenium.[55,56,57,58,59,60] However it should be noted that mega dosages of these micronutrients are not required and that it only affects performance if the athlete have a deficiency of the nutrient.[55,56,57,58,59,60] It should be noted that no conclusions on the total micronutrient intake of the studied group can be made due to a large percentage taking additional supplements and taking into consideration the limitation regarding the interpretation of micronutrient intake of groups with the RDA. Although the dietary micronutrient intake of the study population in general seems adequate and therefore attenuating the need for extra supplementation. In our study the micronutrient intake was compared to the dietary reference intakes and where applicable to specific nutrients the increased requirement for the athletic population. Most of the dietary micronutrient intake was above 133% of the DRI, with a few micronutrients falling well above the upper limit. The micronutrients of concern included iodine, fluoride and vitamin C intake in men and chloride, iodine, fluoride, iron and vitamin C intake of the women. Iodine and fluoride is not a big concern as the athletes will consume this via iodated salt and toothpaste. It is also possible that the athletes did not report the total intake of condiments such as salt, although they were instructed to. A bigger concern is not reaching vitamin C requirements for athletes. Although there were no significant relationship between vitamin C intake and URTI, literature has linked the intake of antioxidants with a reduced prevalence of URTI. It does not however support mega dosages of antioxidant intake.[68,69,70,71,72,73,74]

Eight percent of the women reported that they have been diagnosed with iron deficiency anemia although the dietary intake of iron, vitamin C and protein in the women's diet was adequate. Vitamin C will aid in the absorption of iron and the heme iron sources from protein/animal sources are more bio-available.[40]. Iron is very important for hemoglobin synthesis and a deficiency of iron can definitely impair performance and cause anemia, cognitive damage and immune abnormalities.[181] Only a small percentage of the women reported taking iron supplementation, less than the percentage women who reported that they had diagnosed iron deficiency anemia. It appears that an iron deficiency is more common among female runners as reported by Lukaski et al. 2004[182] The reason why iron deficiency is more prevalent among female runners is that they often consume an inadequate dietary intake of protein and vitamin C, a high dietary intake of fiber, which interferes with iron absorption and the increased losses through menses and losses through sweat.[182] It is important to emphasize a variety of food in the diet of athletes to reach all their requirements.[182]

The majority of the triathletes took a form of multi-vitamin supplementation which shows that they do feel their diet is not providing adequate nutrition. They also indicated an inadequate diet or nutrient replacement as being a popular reason for using supplements. Single vitamins were taken by 65% of the study group, of which all said the single vitamin supplement was vitamin B12. Vitamin B12's relationship toward exercise is that it functions as part of hemoglobin and erythrocyte formation and plays an important role in neurology[183] A deficiency of vitamin B12 is typically characterized by either pernicious or megaloblastic anemia and neurological symptoms occur as a result of this. Symptoms include a weakness of the limbs, feeling of pins and needles in the hands, arms, legs and feet, dysgeusia and irritability.[183] A relative high number of the subjects reported symptoms of pins and needles in the extremities, although there were no significant association between this and dietary intake of vitamin B12, which in this case was adequate. There were also no reported diagnosed vitamin B12 deficiencies and therefore supplementation was not warranted.[184] Vitamin B12 supplementation is only indicated for athletes on energy-restricted diets, vegan vegetarians and subjects with a known vitamin B12 deficiency.[182] As with all the other vitamins and minerals, supplementation will only have a beneficial effect if there is a known deficiency present.[182] Single mineral supplementation was 58% among the studied group, including iron as discussed, calcium and magnesium supplementation, which will be discussed later.

4.8 Dietary Supplements and Ergogenic Aids

In a study by Striegel et al. 2006[184] on Master's athletes, 60.5% reported to take supplements and in the present study, we found a prevalence of 73% of the athletes take dietary supplements.

Most of the triathletes consume some form of a CHO supplement, which coincides with the number one reason given by the athletes why they consume supplements: to increase energy supply. This is additional to their dietary intake and would make up for the inadequacy reported previously in this discussion. CHO can be supplemented in various forms, including gels, drinks, bars and powders. The majority of the triathletes used a form of protein supplementation in addition to dietary intake. As discussed earlier, the dietary protein intake of this group was sufficient and attenuates the need for additional protein supplementation. Single amino acids or powders also featured as 27% of the athletes consumed some form of amino acid supplement. The requirement for protein in endurance athletes are higher than sedentary counter parts (1.2-1.7g/kg body weight vs. 0.8-1g/kg body weight)[185] due to the fact that some amino acids (including the branched chain amino acids) are oxidized in larger amounts during exercise.[185] There are also claims that BCAA have an anticatabolic effect or that it can limit the amount of muscle damage due to exercise. There is however a lack of scientific evidence supporting such claims.[185]

The third group of supplements most commonly consumed by the triathletes was antioxidants. Fifty eight percent (N = 15) of the triathletes take some form of anti-oxidant supplementation, which correlates with the second most common reason given for taking supplements, which is to enhance immune function. As discussed in the literature overview, there is currently no indication for taking any anti-oxidant supplementation to enhance the immune function.[173] Another supplement being used to supposedly enhance the immune function includes glutamine. Four percent (N = 1) of our study population supplemented with glutamine. In the literature however we do not find conclusive evidence suggesting the benefit of supplementing with 5-8g/day of glutamine, for immune function or to enhance performance.[51,52,53]

Eighteen percent (N = 5) of the study population took salt tablets including magnesium, sodium, potassium and chloride as ingredients. Fifty eight percent (N = 15) of the triathletes took single mineral supplements and 27% (N = 7) took magnesium supplementation as daily intake and during training or racing. This is very interesting as no reason was given for the use of these supplements. The triathletes commonly link salt or magnesium tablets or supplementation with experiencing heat muscle cramps and may link the supplementation to reducing muscle cramps. The literature does not support the popular belief that supplementation with magnesium or electrolytes will reduce the prevalence of heat muscle cramps in athletes.[186] The cramping as shown by Sulzer et al. 2005[186] can rather be attributed to increased neuromuscular activity and is not associated with an increase in loss of body weight or serum electrolyte concentrations in Ironman triathletes. Costill et al. 1984[187] found that even with repeated days of sweating, there were no deficits found of magnesium, chloride or potassium and that additional supplementation showed no benefit.[187] It is known that most athletes exercising and sweating for more than 4-5 hours can tolerate sodium losses of up to 10% of body stores and consuming salty food after exercise will replenish sodium stores. Fluid intake is usually linked to electrolyte replacement and is discussed elsewhere.[61,62,63,64,65,66,67]

The prevalence of caffeine supplementation among the athletes was low with only 4% (*N* = 1) using this stimulant of the central nervous system. The Sport Science Institute of South Africa[40] recommends supplementing with 1-3mg/kg body weight of caffeine for a performance enhancement effect and Cox et al. 2002[150] showed an increased fat utilization in the fasted state when ingesting 5-6mg/kg body weight of caffeine.[150] The effect on the central nervous system masks fatigue, increasing exercise endurance. Side effects of caffeine supplementation include nervousness, shakiness, anxiety, heart palpitations, flushing and headaches. It is also known that with a high habitual intake of caffeine [>600mg/day], the effect on performance decreases.[85]

We have shown with this study that the triathletes predominantly supplement with what they believe to provide more energy or enhance their immune function. They are however misguided regarding the use of certain supplements and need to be further educated to make the right choices. It can lead to serious offences when athletes take supplements because of what they believe or hear in the media due to the contamination of supplements or due to ingredients in the supplements not having a beneficial effect on their performance or body composition and being banned by the International Olympic Committee (IOC). A good example of this includes the use of herbal supplements like ginseng, Echinacea, ephedra, inositol, guarana and green tea, which was shown to be quite popular among our triathletes (42%). Some of the herbal supplements like ephedra are banned by the IOC. Whether the athletes are aware of this is unsure.[112] The true benefit of taking these supplements is also not clear as the bulk of scientific evidence available indicate that they do not have additional exercise performance enhancing qualities.

4.9 Medical Complications

Athletes may experience some medical complications during or after a triathlon or as a result of intense daily training. According to Dallam et al. 2005[189], this can include exhaustion, dehydration and muscle cramping as discussed previously, hypothermia, heat stroke, hyponatremia, postural hypotension, musco-skeletal injuries and minor trauma, bacterial infections from exposure to the water, a variety of gastro-intestinal complications, post race immunosuppression discussed previously, sympathetic nervous system exhaustion and heamolysis.[189] A brief description of the various gastro intestinal complications will be discussed here, as well as another complication predominantly found in female athletes known as the female athlete triad.

4.9.1 Gastro-intestinal complications:

Michael et al. 1994[190] reported that up to 30% of elite athletes suffer some form of gastro-intestinal complications during a race. These symptoms varies from gastro-esophageal reflux, epigastric pain, vomiting, diarrhea, ischemic gastritis, abdominal pain and many more.[190] Worme et al.[172] reported the prevalence of gastro-intestinal symptoms among 18 female and 49 male triathletes. (Figure 4.3) The authors reported that there was a high incidence of upper gastro-intestinal symptoms that could have been due to CHO malabsorption or alterations in gastric motility.[172]

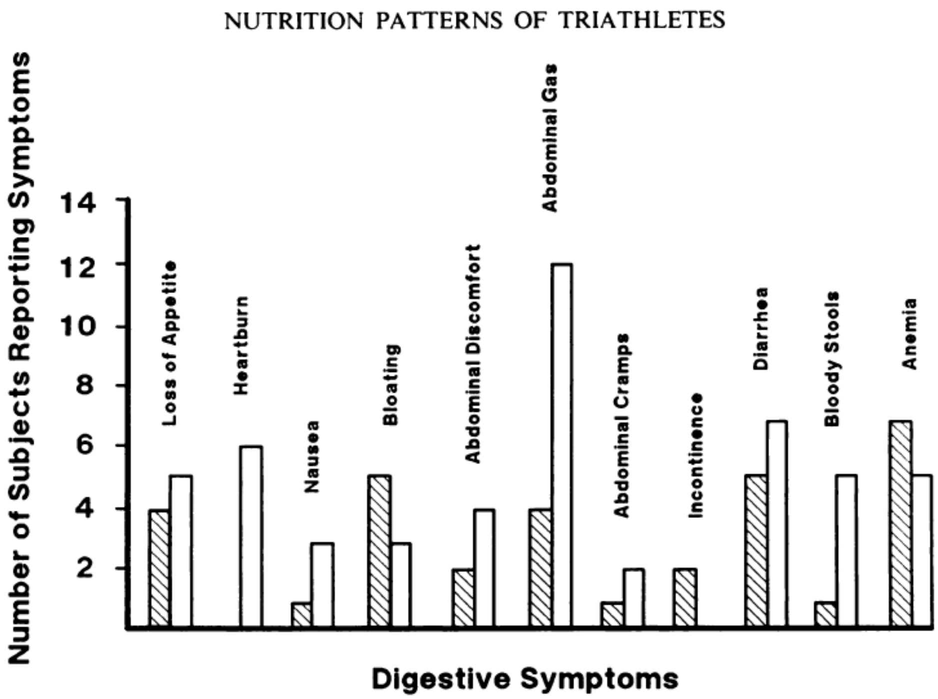

FIG 3. The number of women out of 18 (hatched bars) and men out of 49 (open bars) who reported positive responses (frequent or disabling) to specific digestive or gastrointestinal symptoms.

Figure 4.3 Incidence of digestive symptoms in 18 female and 49 male triathletes.
Source: Worme et al. 1990[172]

In our study, the authors found that among the triathletes, 12% recorded that irritable bowel syndrome has been previously diagnosed. Four percent of the subjects suffer from chronic flatulence. This can aggravate gastro-intestinal distress during a training session or race and can leave the athlete feeling uncomfortable and subsequently decrease performance. This irritable bowel syndrome can also be a reason why 8% of the triathletes felt fatigued all the time.[3] These are due to the fact that intense exercise, sleeping disorders, stress and diet all play a role in the etiology of IBS.[3] Ultra-endurance racing and training sessions can cause GIT ischemia, which can lead to gastro-intestinal complications outside of the racing or training environment.[191,192,193,194,195,196,197]

Gastro-intestinal comfort is of the utmost importance in athletes as a high carbohydrate or high fibre intake may lead to gastro-intestinal upset. Gastro-intestinal symptoms can be disabling for athletes if it occurs frequently.[172] When care is taken to adhere to timing, frequency and amount of carbohydrate intake, no gastro-intestinal side effects will occur. The possibility of including pre –and or probiotics in the diet have also been studied without much success.[198]

Tailored dietary advice forms an integral part of maintaining gastro-intestinal comfort and the athletes should focus on individual preference and comfort when consuming carbohydrate in meals or as supplements. Increased intakes of fructose, lactose and insoluble fiber can aggravate gastro-intestinal symptoms, whilst the intake of soluble fiber can relieve symptoms.[3] Before or during competitions or races fiber, fructose and lactose should be avoided and preference should be given to glucose and glucose polymers.[26]

4.9.2 Female athlete triad

The female athlete triad is "abnormal eating patterns associated with menstrual dysfunction and a subsequent decrease in bone mineral density or osteoporosis. The 3 conditions i.e. disordered eating, amenorrhea and osteoporoses may occur together in female athletes".[199] The etiology of the female athlete triad (Figure 4.4) indicate that several factors play a role, including athletic performance pressure, pressure for thinness, societal stress and negative self-appraisal.[199] The importance of preventing the female athlete triad, the athlete needs to achieve and maintain energy balance.[199] The disordered eating often lead to an increased risk of injury, amenorrhea, fluid and electrolyte imbalances, impairment of athletic and work performance and serious psychological and medical complications.[199] In our study, we did not test for disordered eating, but did find that some of the female athletes did not have a regular menstrual cycle. A number of the female athletes also reported drinking medication to stop them from menstruating for prolonged periods of time. In the long term this can lead to menstrual irregularities, negative influence on bone health and fertility problems.

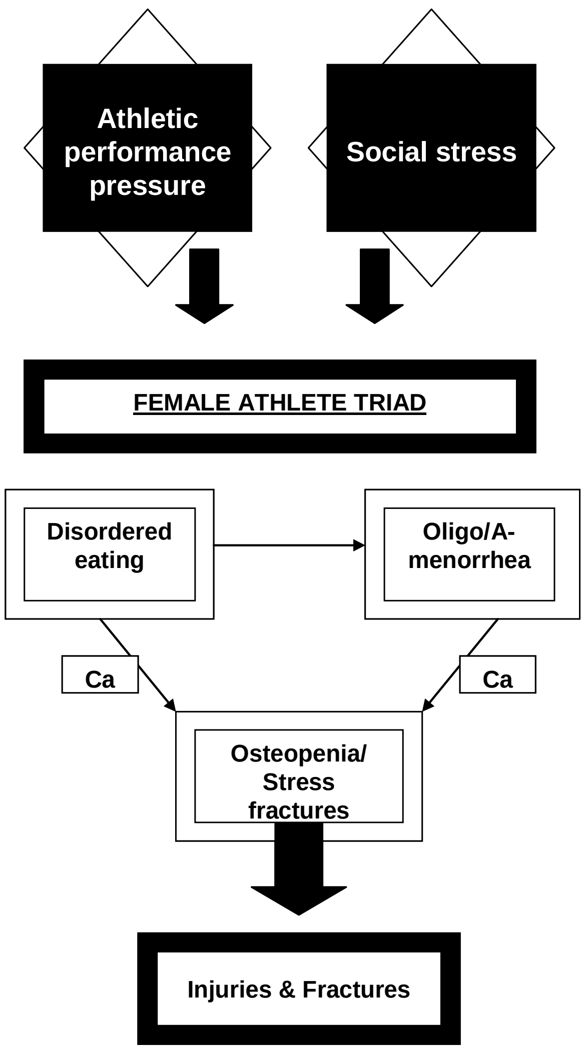

Figure 4.4 The female athlete triad
Source: Adapted from Thrash et al, 2000.[199]

4.10 Shortcomings and Limitations of the Study

The shortcomings of the study include the limited sample size. An increased sample size would give more in depth insight regarding the body composition, dietary intake and supplement use of triathletes.

Assumptions of the study included assuming that the triathletes taking part are in training phase during the data collection period as the triathlon season in South Africa starts in spring time. Winter usually provide the opportunity for duathletes to compete. The inclusion criteria however included that athletes must be training more than 10 hours per week, irrespective of the phase of training they were in. We also assume that subjects adhered to pre-test conditions and except that not all athletes necessarily complied. It is assumed that the dietary record keeping and report of supplement use was accurate.

A limitation of the study is the inclusion of and the fact that the study population consist of elite and amateur. The inclusion of 3 elite athletes might have skewed the results. Another limitation of the study was that only 69% of the triathletes completed and returned their food record booklets over a 1.5 year data collection period. Future studies in this field should quantify macro- and micro-nutrients from supplements as well as dietary intake.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The importance of determining nutritional status in athletes is highlighted in this study. Body composition, dietary intake and supplement use affect the ability of athletes to train well and by training well, they increase their chances of performing optimally or winning. In the present study, we found that two of the popular field methods for determining percentage body fat in athletes do correlate well when the appropriate equations are used. This necessitates the importance of sport specific and population specific prediction equations from skinfold measurements. The MF-BIA is a quick and easily administered method of determining percentage body fat and body composition in general and has a widespread use in the field of sport nutrition. The fact that the measurements correlated so well with most of the prediction equations illustrates this point.

Triathletes always strive toward achieving the lower ranges of ideal body weight or the lower ranges of percentage body fat. The reason for this being that this increases the power to weight ratio and can dramatically improve exercise performance.[171] The higher the amount of fat in the body, the harder the athlete has to work over a specified distance to achieve the same results as his/her peers with less body fat.[171] The athletes in our study group bordered at the high ends of the optimal range for endurance triathletes. A reason why this is prevalent can be due to the fact that we included elite and amateur triathletes in our study.

The dietary intake in the present study emphasized the need to achieve optimal total energy and more importantly carbohydrate intake. Without reaching this optimal intake the athlete increases his/her chances of experiencing fatigue and immunosuppression in the form of URTI's. Syndromes like the female athlete triad occur when there is a disturbance in energy balance and drastically lead to a decrease in performance.

From the literature we see athletes tend to have a habitual high protein intake and this is further emphasized by our results and it reduces the need for any additional protein supplementation. The men and women had a high fat intake

Dietary intake has a definite effect on health status as shown by the results. Various micronutrient deficiencies can result in a decrease in performance. The important factor here is that if the athlete does not have a known deficiency, no amount of supplementation will prove beneficial. As described by the dietary micronutrient intake of our study population, there is little evidence suggesting such deficiencies. A reduced intake of iron and vitamin C among the women were still within the ranges from the DRI, which leads to more questions being asked, i.e. is the extra supplementation for physical exercise really necessary?

The use of dietary supplements among the group was very wide, supplements ranged from carbohydrate supplement with a known ergogenic effect to supplements like carnitine not being scientifically and practically proven as an ergogenic aid. Triathletes should be aware of the mass marketing of supplements and be able to make informed choices. Not only is an unnecessary amount of supplementation not cost effective, it also places the athlete at a risk for ingesting banned substances or ingredients without them being aware of this. Contamination of supplements is a wide spread phenomenon which should not go unnoticed. This counts especially for the large amount of athletes taking herbal supplementation, which has no proven benefit and might be harmful or illegal.

5.2 Conclusion

The author would like to conclude that body composition, dietary intake and supplement use of triathletes are very important aspects of their performance. The nutritional status of triathletes will influence their ability to deal with an increased training demand, a challenging racing schedule and maintaining the optimal health to provide consistent and good results throughout their athletic careers. The body composition of the triathletes in the Western Cape region was normal and indicative of amateur athletes. They had sufficient macro –and micronutrient intake and maintained energy balance. Supplement use was popular among the triathletes, although care should be taken regarding unnecessary supplementation

5.3 Recommendations

Recommendations for future studies would be to include a larger study population. This is especially important when the aim of the study is to compare anthropometry with bio-electrical impedance analysis. It would also be beneficial to divide the study population into groups for elite athletes and age group athletes. Studying these subjects in groups according to the different distances of triathlon would also be beneficial for the specific groups. Future studies can go into more depth regarding quantifying the supplements used by the athletes and adding this to the habitual dietary intake.

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Appendix 2.1: Food Record Booklet

Body Composition, Dietary Intake and Supplement use among Triathletes residing in the Western Cape Region

Food Record Booklet

Principle Investigator: Sunita Bam RD (SA)
Co-Principle Investigators: Prof D Labadarios and Mrs. I Labuschagne

Site: 238 Sarel Cilliers Street, Strand, 7140

Date of this Report: ______________________

Days on which you must keep record:

Weekday:	
Weekday:	
Weekend day:	

NB: Please read instructions carefully before you start recording!

Contact information:
Sunita Bam RD (SA): 082 335 3650 or sunitabam@mweb.co.za

Reporter's signature:

____

Instructions:

1. Please return the completed 3 Day Record and supplement table when you have completed it, by placing it in the enclosed envelope (postage already paid) and mailing it (enveloped is addressed)
2. Remember not to deviate from your normal dietary intake; it may influence the results of the study.
3. Keep your dietary record book with you on the specific days and immediately record food and liquid as it is consumed.
4. When recording, use one line per food item. Begin each day on a new page.
5. Detailed information is essential. Food and liquid consumed must be described in detail and a careful estimate must be made of the portion size. Where applicable preparation methods or brand names must be given. When eating out or ordering a take-away, the restaurant name and name of dish/item and portion size should be given. All snacks should be noted.

Guidelines:

1. Describe the food e.g. brown bread or white rice.
2. Note whether the bread is home sliced, whether it is thinly, and medium or thickly sliced or machine sliced. Name the bread type, i.e. white, brown, whole-wheat seed loaf and note the dimensions of the rolls.
3. Describe the amounts in household measures, e.g. a teaspoon, dessert spoon, table spoon, ladle, ½ cup, cup. Also add whether the spoon was heaped or level.
4. Measurements can also be given in cm, e.g. one piece of cheddar cheese, 5cm by 5cm and 2cm thick. Size could also be given based on matchbox measurements. Use the ruler provided for this purpose.
5. Give the container or wrapper size where possible; yoghurt 175ml, chocolate, 100g
6. Specify whether the margarine used is either hard (brick), or soft (tub).
7. When eating a combined dish e.g. a stew or pasta dish, name all the ingredients of the dish i.e. cabbage stew, cottage pie.
8. Give preparation method, e.g. one extra large egg fried in oil; ½ cup
9. Milk/powder milk must be specified as full cream, 2% or skimmed milk. Give the brand name in case of milk powder.
10. Remember to give names and amounts of all cold drinks, juice and alcoholic beverages.

Supplements:

1. Please state clearly the brand and the name of the supplement you use
2. Indicate how many times a day you take the supplement and how much of the supplement you take at a time (see the example)

Example...

Day:			
Time:	Item eaten:	Amount:	Official Use:
8 am	Mealie porridge, soft	½ cup	
	2 % milk	¼ cup	
	White sugar	2 teaspoons heaped	
	Sasko Dumpy brown bread	1 slice, 1cm thick, machine sliced	
	Stork margarine, tub	Medium spread	
	Fine apricot jam	Thickly spread	
	Tea	1 cup	
	2% milk	6 tablespoons or ¼ cup	
	White sugar	2 level teaspoons	
1 pm	White bread roll	1 round, 6.5cm diameter	
	Margarine, stork, tub	Medium spread	
	Tomato slices	4 thin slices, medium tomato	
	Polony	2 large slices, machine sliced	
	Coca-cola	1 can, 340ml	
3 pm	Granny smith apple	2 small	
7 pm	Cabbage stew: cabbage, beef, potato, onion fried in oil, water added	1 ½ cup	
	White rice, boiled	2 cups	
	Mixed vegetables, boiled	½ cup	
	Tea	1 cup	
	2% milk	6 tablespoons or ¼ cup	
	White sugar	2 level teaspoons	
9 pm	Boiled sweets, sparkles	2	

Day:			
Time:	Item eaten:	Amount:	Official Use:

Day:

Time:	Item eaten:	Amount:	Official Use:

Day:

Time:	Item eaten:	Amount:	Official Use:

Supplements:

Name as printed on package	Dose (ml/ number of pills)	Frequency (1/2/3 times per day)	Date started	Date stopped	Duration of taking the supplement
Wyeth, Centrum	1 tablet	Daily	1 Jan 06	31 Dec 06	1 year
Vitargo	One scoop to 500ml water	Immediately after training	10 Jan 07	-	> 2 months

Name as printed on package	Dose (ml/ number of pills)	Frequency (1/2/3 times per day)	Date started	Date stopped	Duration of taking the supplement

Specific Reasons for taking supplements:

____

____

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Thank you for completing the FOOD RECORD!!

Appendix 2.2: United States Olympic Committee athlete profile medical history questionnaire

United States Olympic Committee

ATHLETE PROFILE
MEDICAL HISTORY QUESTIONNAIRE
2007 PAN/PARAPAN AMERICAN GAMES

NAME: ____ **SPORT:** ________________________

DATE OF BIRTH: _____________________________________ **GENDER: FEMALE** ☐ **MALE** ☐

ADDRESS: ____

CITY: _____________________________________ **STATE:** ___________________________ **ZIP:** _____

EMERGENCY CONTACT NAME: ____

PHONE: (___) ___ - ____

Please select "Yes" or "No" and provide additional details where requested on this form.
All information will be confidential.

1. Have you had a medical illness or injury since your last check up or sports physical? ☐Yes ☐No
2. Do you have an ongoing or chronic illness? ☐Yes ☐No
3. Are you allergic to any medication (aspirin, penicillin, sulfa, etc.)? ☐Yes ☐No
(List: ____
____)
4. Do you have any food allergies? ☐Yes ☐No
(List: ____
____)
5. Do you have any seasonal allergies that require medical treatment? ☐Yes ☐No
(List: ____
____)
6. Are you allergic to insect bites? ☐Yes ☐No
(List: ____
____)
7. Do you take any over the counter medication(s)? ☐Yes ☐No
(List: ____
____)
8. Do you take any prescribed medication on a permanent or semi-permanent basis (steroids, birth control pills, anti-inflammatories, antibiotics, etc.)? ☐Yes ☐No
(List: ____
____)
9. Do you use an inhaler? ☐Yes ☐No
(List: ____
____)

10. Do you take any over the counter dietary supplements (herbs, vitamins, minerals, protein)? ☐Yes ☐No
(List: ____
____)

11. Have you ever taken any dietary supplements or vitamins to help you gain or lose weight or improve your performance? ☐Yes ☐No
(List: ____
____)

12. Do you ever have chest tightness? ☐Yes ☐No

13. Do you ever have wheezing? ☐Yes ☐No

14. Do you ever have itchy eyes? ☐Yes ☐No

15. Do you ever have itching of the nose or throat or sneezing spells? ☐Yes ☐No

16. Does running ever cause chest tightness or cough or wheezing or prolonged shortness of breath? ☐Yes ☐No

17. Have you ever had chest tightness, cough, wheezing, asthma or other chest (lung) problems which made it difficult for you to perform in sports? ☐Yes ☐No

18. Have you ever missed school, work or practice because of chest tightness or cough or wheezing or prolonged shortness of breath? ☐Yes ☐No

19. If you have been told you have asthma, what medication(s) have you taken to treat it?
(List: ____
____)

20. Have you ever had a rash or hives develop during or after exercise? ☐Yes ☐No

21. Have you ever had a seizure? ☐Yes ☐No
(List medication(s):____
____)

22. Have you ever been told that you have epilepsy? ☐Yes ☐No
(List medication(s):____
____)

23. Do you have or have you ever been treated for diabetes? ☐Yes ☐No
(List medication(s):____
____)

24. Have you ever been told that you were anemic? ☐Yes ☐No
(When:____
____)

25. Have you ever been told that you have sickle cell anemia? ☐Yes ☐No

26. Have you ever been told by a physician you have the sickle cell trait? ☐Yes ☐No

27. Have you ever become ill from exercising in the heat? ☐Yes ☐No

28. Have you ever passed out in the heat? ☐Yes ☐No

29. Have you ever had heat or muscle cramps? ☐Yes ☐No

30. Have you ever been told to give up sports because of health problem? ☐Yes ☐No

31. Has anyone in your family under age 50 died suddenly? ☐Yes ☐No

32. Do you have or have you ever had high blood pressure? ☐Yes ☐No
(List medication(s):____
____)

33. Do you have or have you ever had high cholesterol? ☐Yes ☐No

34. Do you have trouble breathing or do you cough during or after activity? ☐Yes ☐No

35. Have you ever been dizzy during or after exercise? ☐Yes ☐No

36. Have you ever fainted or passed out when exercising? ☐Yes ☐No

37. Have you ever had chest pain during or after exercise? ☐Yes ☐No

38. Do you have or have you ever had racing of your heart or skipped heartbeats? ☐Yes ☐No

39. Do you get tired more quickly than your friends do during exercise? ☐Yes ☐No

40. Do you have or have you ever been told you have a heart murmur? ☐Yes ☐No
(Give date(s): ____
____)

41. Do you have a heart arrhythmia? ☐Yes ☐No
(List medication and dosage: ____
____)

42. Do you have a family history of heart disease? ☐Yes ☐No
Describe ____
____

43. Do you have any other history of heart disease? (angina, arrhythmia, valve disease) ☐Yes ☐No
Describe ____
____

44. Have you had a severe viral infection (for example myocarditis or mononucleosis) within the last month? ☐Yes ☐No

45. Do you have or have you ever had rheumatic fever? ☐Yes ☐No
(Give date(s): ____
____)

46. Do you have or have you ever had lung disease (pneumonia)? ☐Yes ☐No
(Give date(s): ____
____)

47. Do you have or have you ever had kidney disease (infections)? ☐Yes ☐No
(Give date(s): ____
____)

48. Do you have or have you ever had liver disease (mononucleosis, hepatitis)? ☐Yes ☐No
(Give date(s): ____
____)

49. Do you or have you ever had a hernia or "rupture"? ☐Yes ☐No
Has it been repaired? ☐ Yes ☐No

50. Do you have any current skin problems (for example, itching, rashes, acne, warts, fungus, or blisters)? ☐Yes ☐No

51. Have you been "knocked out," become unconscious, or lost your memory? ☐Yes ☐No
(Give date(s): ____
____)

52. Have you had a concussion or other head injury? ☐Yes ☐No
(Give date(s): ____
____)

53. Have you ever had your head or neck x-rayed? ☐Yes ☐No

54. Have you stayed overnight in a hospital due to head injury? ☐Yes ☐No
(Give date(s): ____
____)

55. Do you have frequent or severe headaches? ☐Yes ☐No

56. Have you ever had a neck injury involving bones, nerves or discs that disabled you for a week or longer? ☐Yes ☐No
(Type of injury: ____
Dates: ____)

57. Have you ever had numbness or tingling in your arms, hands, legs, or feet? ☐Yes ☐No

58. Have you ever had a stinger, burner, or pinched nerve? ☐Yes ☐No

59. Have you ever injured your back? ☐Yes ☐No
(Type of injury: ____
Dates: ____)

60. Do you have back pain? ☐Yes ☐No
(Check those which apply: ☐ seldom ☐ occasionally ☐ frequently ☐ with vigorous exercise ☐ with heavy lifting)

61. Do you want to weigh more or less than you do now? ☐Yes ☐No

62. Do you lose weight regularly to meet weight requirements for your sport? ☐Yes ☐No

63. Do you feel stressed out? ☐Yes ☐No

64. Have you had any other problems with pain or swelling in muscles, tendons, bones, or joints? If yes, check which apply and explain. ☐Yes ☐No
(☐head / ☐ neck / ☐ back / ☐ chest / ☐ shoulder/ ☐ upper arm / ☐ elbow/ ☐ forearm / ☐ wrist / ☐ hand / ☐ finger / ☐ hip / ☐ thigh / ☐ knee / ☐ shin/calf / ☐ ankle/ ☐ foot)
Explain: ____
____

65. Have you had a broken bone or fracture? ☐Yes ☐No
☐ R or ☐ L (What bone(s) ______________________________
Dates: ______________________________)

66. Have you had a shoulder injury that disabled you for a week or longer (dislocation, separation, etc.)? ☐Yes ☐No
(Type of injury: ______________________________
Dates: ______________________________)

67. Have you ever had a shoulder surgery? ☐Yes ☐No
☐ R or ☐ L
(What was done & why: ______________________________
Dates: ______________________________)

68. Does your shoulder routinely/occasionally dislocate (come out of place)/sublux? ☐Yes ☐No

69. Have you injured your knee? ☐ R or ☐ L ☐Yes ☐No

70. Have you been told by a doctor or athletic trainer that you injured the cartilage in your knee? ☐ R or ☐ L ☐Yes ☐No
(Give date(s) ______________________________)

71. Have you been told by a doctor or athletic trainer that you injured the ligaments in your knee? ☐ R or ☐ L ☐Yes ☐No
(Give date(s) ______________________________)

72. Have you ever had knee surgery? ☐ R or ☐ L ☐Yes ☐No
(What was done: ______________________________
Dates ______________________________)

73. Have you had a severe ankle sprain? ☐ R or ☐ L ☐Yes ☐No

74. Do you have a pin, screw or plate in your body? ☐Yes ☐No
(Where in your body: ______________________________
Dates: ______________________________)

75. Have you had any surgery? ☐Yes ☐No
Specify and give details: ______________________________

76. Do you use any special protective or corrective equipment or devices that are not usually used for your sport (for example, knee brace, special neck roll, foot orthotics, hearing aid)? ☐Yes ☐No

77. Have you had any problems with your eyes or vision? ☐Yes ☐No

78. Do you wear glasses, contacts or protective eyewear during competition? ☐Yes ☐No

79. Do you have a hearing loss? R= ______ L= ______ ☐Yes ☐No
% of hearing loss? R= ______ L= ______
Do you use an appliance? ______________________________
Type? ______________________________

80. Do you wear any of the following dental appliances? ☐Yes ☐No
(Circle those which apply: ☐ permanent bridge / ☐ removable retainer / ☐ removable partial plate ☐ permanent crown or jacket / ☐ braces / ☐ permanent retainer / ☐ full plate)

81. Are you missing one of a set of paired organs (kidney, eyes, etc.)? ☐Yes ☐No
(List: ____
____)

82. Do you now or have you ever had herpes? ☐Yes ☐No

FEMALES ONLY

83. At what age was your first menstrual period? _____

84. When was your most recent menstrual period (mm/yr)? _____

85. How much time do you usually have from the start of one period to the start of another (number of days)? _____

86. How many periods have you had in the last year? _____

87. What was the longest time between periods in the last year (number of days)? _____

88. Are you pregnant, or do you suspect that you may be pregnant? ☐Yes ☐No

(If the answer is "Yes," this does not necessarily preclude your participation from your sport, however you must present a clearance form you physician stating that your sport participation will not be detrimental to the pregnancy.)

89. Do you have any other conditions that we should be aware of (i.e. ulcers, tendonitis, etc.)? ☐Yes ☐No
Specify and give details: ____

90. Please give the date of your last immunizations (mm/yr):
Tetanus: _____ Polio: _____ Hepatitis B: _____

91. Please give the date of your last measles, mumps, rubella and chicken pox shots (mm/yr):
Measles: _____ Mumps: _____ Rubella: _____ Chicken Pox: _____

92. Which of the following dietary supplements have you taken **during the past year**?
☐ Multi-vitamin/minerals
☐ Individual vitamin (e.g. vitamin C, etc.)
☐ Individual mineral (e.g. iron, calcium, etc.)
☐ Protein powders or pills
☐ Herbals (e.g. Ginseng, Echinacea, etc.)
☐ Protein drinks or bars
☐ Energy drinks or bars
☐ Creatine
☐ Amino acid pills or powders
☐ Others – please list
_____

93. If you took any dietary supplements during the past year, how frequently did you take them?
☐ Daily
☐ Once a week
☐ Only at specific times (travel, training, etc.)
☐ Occasionally
☐ Several times a week

94. Check the reasons for using dietary supplements **during the past year**:
☐ To make up for an inadequate diet
☐ To treat a medical condition or injury
☐ To increase muscle mass/gain weight
☐ To prevent illness and disease
☐ To lose weight
☐ To have more energy
☐ To enhance my performance
☐ No specific reason

I hereby state that the questions on this form have been answered completely and truthfully to the best of my knowledge.

Name of athlete: ____
(please print)

Signature of athlete: ____________________________________Date: ______________

Noteworthy medical conditions/issues as per Medical Staff review:

____

____

____

____

____

____

____________________________________ ______________
Medical Staff signature **Date**

USOC, International Games, 1 Olympic Plaza, Colorado Springs, Colorado 80909 / tel: (719) 866-2060 / fax: (719) 866-4966 / denise.thomas@usoc.org

Additional to the US Olympic Committee Questionnaire:

Physical Exercise:

1) How often do you exercise:

____

2) How many hours a week do you spend:

Swimming: ____________________

Cycling: ____________________

Running: ____________________

Gym training (Resistance):

3) How many kilometers a week do you:

Swim: ____________________

Cycle: ____________________

Run: ____________________

General:

1) Have you recently had unexplained weight loss?	YES	NO
2) Have you recently had unexplained weight gain?	YES	NO
3) Do you suffer from chronic fatique?	YES	NO
4) Have you recently experienced a change in appetite?	YES	NO
5) Do you suffer from any gastro-intestinal problems?	YES	NO

Specify: ____

Personal Habits:

TOBACCO:

1) Do you live with people who smoke? | YES | NO |

2) Did your parents smoke when you were growing up? | YES | NO |

3) Have you ever used tobacco? | YES | NO |

4) Do you currently use tobacco? | YES | NO |

Duration:____

Frequency:____

ALCOHOL:

1) Do you drink alcoholic beverages? | YES | NO |

Amount:____

Frequency:____

Type:____

2) Have you used alcohol in the past but subsequently quit? | YES | NO |

3) Do you now have or have you ever had problems with excessive alcohol use?

| YES | NO |

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Specify: ____

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