



Epidemiology and risk factors for illness in athletes participating in sport tournaments or competitions – a specific focus on Rugby Union

A dissertation prepared by Alan Kourie (KRXALA001) in partial fulfilment of the requirements for the Master of Philosophy degree in Sport and Exercise Medicine (MPhil Sport and Exercise Medicine) from the University of Cape Town

July 2015

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

Declaration

I, Alan Kourie, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

No part of this dissertation may be reproduced, stored in a retrieval system, or transmitted in any form or means without prior permission in writing from the author or the University of Cape Town.

X

Alan Kourie
Doctor

.....

.....

(Signature)

19 July 2015

Acknowledgements

- Kelly, who during this thesis time has been my girlfriend, fiancée and now my beautiful wife - your love, belief and support throughout this journey has been a constant source of encouragement. I am forever grateful for you, and for all that you did to help me focus on the task at hand. I will always appreciate the countless dinners that were prepared for me so that I could work and the lonely nights you endured while I sat in front of the computer
- My parents for always believing in me and selflessly providing me with every opportunity in life. You have set the bar exceptionally high
- My brothers, Craig and Marc and sister Jade for their love and support
- Professor Martin Schwellnus, for his expert guidance, assistance and unwavering commitment despite significant personal life changes. You and Wayne have been my inspiration for Sports Medicine
- The Super Rugby Doctors', for collecting and collating the data, one of whom I am now privileged to be
- Our statistician, Esme Jordaan for the analysis of the data
- Professor Wayne Derman and Clint Readhead in the study concept design

Table of contents

	Page
Declaration	2
Acknowledgements	3
Table of contents	4
List of Tables	6
List of Abbreviations	9
Abstract	11
Chapter 1: Introduction and scope of the thesis	13
Chapter 2: A review of the epidemiology and risk factors for illnesses in athletes participating in sport tournaments or competitions - a specific focus on Rugby Union	16
Chapter 3: Intrinsic risk factors associated with illnesses during the 2010 Super Rugby tournament - a prospective cohort study involving 22676 player days	43
Chapter 4: Summary and conclusions	69
References	76
Appendices	80
Appendix A: Participant Information Sheet	80
Appendix B: Informed Consent Form	102

List of Tables

	Page
Table 2.1. A summary of extrinsic and intrinsic risk factors for illness in athletes (including level of evidence for risk factors)	40
Table 3.1. Demographic data for the study population (all players, teams and player position) Values are mean (SD)	45
Table 3.2. The number of players (and % players) in the no illness (control), any illness, respiratory illness, and gastrointestinal (GIT) illness groups. The number of players in each group by team is also included	47
Table 3.3. A training history (% players) in the last 15 weeks and the last 2 weeks according to days and hours per week, and type of training (rugby, strength, endurance and flexibility)	48
Table 3.4. History of medication use (% players), supplement use (% players) and lifestyle habits (% players ever smoking, and weekly alcohol intake) in rugby players with no illness (control group) and players with any illness	50
Table 3.5. Family history of asthma or allergies (% players) in rugby players with no illness (control group) and players with any illness	50
Table 3.6. History of immunizations (% players) in rugby players with no illness (control group) and players with any illness	51
Table 3.7. History of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness (% players) in rugby players with no illness (control group) and players with any illness	52

Table 3.8.	A training history (% players) in the last 15 weeks and the last 2 weeks according to days and hours per week, and type of training (rugby, strength, endurance and flexibility)	53
Table 3.9.	History of medication use (% players), supplement use (% players) and lifestyle habits (% players ever smoking, and weekly alcohol intake) in rugby players with no illness (control group) and players with respiratory illness	54
Table 3.10.	Family history of asthma or allergies (% players) in rugby players with no illness (control group) and players with respiratory illness	54
Table 3.11.	History of immunizations (% players) in rugby players with no illness (control group) and players with respiratory illness	55
Table 3.12.	History of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness (% players) in rugby players with no illness (control group) and players with respiratory illness	55
Table 3.13.	A training history (% players) in the last 15 weeks and the last 2 weeks according to days and hours per week, and type of training (rugby, strength, endurance and flexibility)	57
Table 3.14.	History of medication use (% players), supplement use (% players) and lifestyle habits (% players ever smoking, and weekly alcohol intake) in rugby players with no illness (control group) and players with digestive system illness	58
Table 3.15.	Family history of asthma or allergies (% players) in rugby players with no illness (control group) and players with digestive system illness	59
Table 3.16.	History of immunizations (% players) in rugby players with no illness (control group) and players with digestive system illness	59

Table 3.17.	History of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness (% players) in rugby players with no illness (control group) and players with digestive system illness	60
Table 3.18.	Independent risk factors associated with any illness, respiratory system illness and digestive system illness in rugby players (multiple regression analysis)	61

List of Abbreviations

IOC	International Olympic Committee
IP	Incidence Proportion
IF	International Federations
FIFA	Fédération Internationale de Football Association
IIHF	International Ice Hockey Federation
IAAF	International Association of Athletics Federations
FINA	Federation Internationale de Natation Aquatics
URI	Upper Respiratory Infections
URTI	Upper Respiratory Tract Infection
PCR	Polymerase Chain Reaction
URT	Upper Respiratory Tract
AIS	Australian Institute of Sport
TD	Travellers' Diarrhoea
IR	Incidence Rate
PM	Particulate Matter
TeamGB	Team Great Britain
EYOF	European Youth Olympic Festival
BMI	Body Mass Index
BC	Body Composition

DXA	Dual-Energy X-ray Absorptiometry
NKCA	Natural Killer Cell Activity
sIgA	Secretory Immunoglobulin A
OTS	Overtraining Syndrome
EIA	Exercise-Induced Asthma
EIA _n	Exercise-Induced Anaphylaxis
EIU	Exercise-Induced Urticaria
NSAID	Non-Steroidal Anti-Inflammatory Drugs
DE	Disordered Eating
LEA	Low Energy Availability
ReD-S	Relative Energy Deficiency in Sport
CHO	Carbohydrate
UCT	University of Cape Town
SARU	South African Rugby Union
IFN- γ	Interferon Gamma
URS	Upper Respiratory Symptoms
IgM	Immunoglobulin M

Abstract

Background: Illness in athletes is an inevitable part of participation in sports, and can significantly interfere with training, during tournaments or at competition time. The incidence of illness in sports varies in different sporting codes and across different tournaments and competitions. The Super Rugby competition is a particularly demanding 16-week tournament among countries in the Southern Hemisphere, and is associated with a high incidence of illness. In this tournament, 15 rugby union teams compete and play international level matches every week, which involves travel across numerous time zones and therefore may be associated with a higher incidence of illness in players.

Objective: The main objectives of this dissertation were to 1) review the epidemiology and risk factors for illness in athletes participating in tournaments or competitions, and 2) determine which intrinsic risk factors predispose players to illness during the 2010 Super Rugby tournament.

Methods: This dissertation consisted of two main phases. In phase I, a systematic review of the literature was undertaken, using evidence-based criteria, to determine which risk factors predispose athletes to illness during tournaments. In phase II, a prospective cohort research study was undertaken, involving 239 players from South Africa and New Zealand, over the 16-week duration of the 2010 Super 14 Rugby Union tournament. For phase II, a pre-season medical questionnaire was administered to determine baseline medical data. Collection of data then took place each day of the competition, beginning 7 days before the first game the team played, and ending when each team played their final game. Each team physician completed a daily "medical illness log" for every player. Booklets were supplied that contained daily illness report forms.

Results: The main findings of the review (phase I) were good evidence (level I and II) indicating that 1) international travel, and the duration of a tournament are extrinsic risk factors for illness in athletes, and 2) that prolonged and high intensity training, older age, and nutritional deficiencies are intrinsic risk factors for illness in athletes. The main findings of the prospective cohort study (phase II) were that an increased number of training days in the 2 weeks before the tournament was an independent risk factor for any illness, respiratory system illness, and digestive system illness; the % time spent on endurance training in the 15 weeks before the tournament was an additional independent risk factor associated with respiratory system illness; the use of anti-

inflammatory medication was an independent risk factor associated with respiratory system illness.

Summary and conclusion: In summary, novel intrinsic risk factors for illness in rugby players participating in the Super Rugby tournament were training more days/hours per week in the 2 weeks before the tournament, as well as endurance-type training 15 weeks before the tournament. These data can form the basis of planning preventative strategies to reduce the risk of illness in the Super Rugby tournament.

Keywords: illness, epidemiology, incidence, rugby union, risk factors

Chapter 1

Introduction and scope of the thesis

Injuries and illnesses are an inevitable part of sports participation. Athletes, although normally fit and healthy, are just as susceptible to illness as the general population. In fact, there is evidence [1] to suggest that during periods of high intensity training or prolonged endurance-type training, that athletes for a brief period up to 72 hours may have a temporarily depressed immune system and hence may in fact be more susceptible to illness.

The International Olympic Committee (IOC) [2] and other sporting bodies, have increasingly recognized that illness is an important component of athlete medical care. In recent years, there have been more studies documenting the incidence and risk factors for illness in athletes participating in tournaments and competitions. Protecting the health of the Olympic athlete is the highest priority of the International Olympic Committee (IOC) Medical Commission [3] resulting in an increase in the allocation of resources to injury and illness surveillance and the prevention of adverse health events.

Elite athletes are frequently required to travel long distances for major competitions [4]. The modern day athlete frequently attends training camps away from their home country, and may participate in multiple tournaments in a calendar year. The duration of these tournaments may vary from days to weeks. Despite the improved fitness and conditioning of athletes, the most common reason to miss training or competition, whilst abroad, is illness [5]. Illness significantly affects athletes, coaches and medical teams, and can result in loss of time during periods of conditioning and preparation. More importantly, illness can result in the inability to compete and therefore detract from the many hours of preparation for competitions. Therefore, appropriate medical care to prevent and treat illness has become indispensable to success in competitive sports [6].

Rugby Union is one of the world's most physically demanding contact team sports. It is played in numerous countries around the world, and is also one of South Africa's most popular professional team sports. While rugby injuries have been well documented, the incidence of illnesses in rugby players is not as well documented.

The Super Rugby tournament is a 16-week, annual tournament held in the southern hemisphere. It was introduced in 1996 and was the first fully professional rugby tournament at that time, involving 10 teams. Its popularity grew over the years and has now expanded to involve 15 teams from the southern hemisphere. The tournament is played over a 4-month period in the first half of the year between teams from South Africa, Australia and New Zealand. Teams play most weekends for the duration of the 16-week tournament. The competition is generally regarded as one of the most demanding rugby competitions in the world, placing exceptional physical and emotional stresses on the players. Furthermore, teams have to travel across multiple time zones as matches are played in venues in all three countries, resulting in very demanding travel schedules. This exposes players to different allergens and pathogenic organisms, as well as climatic changes, environmental conditions and differing diets.

In a study conducted during the 2010 Super Rugby tournament, it was found that the incidence of illness was 20.7/1000 player days, and was highest in the respiratory system (30.9%) followed by the digestive system (27.5%) [7]. This is consistent with the findings of other illness studies during competitions. It was also recorded that infections accounted for 54.5% of all illness and 26.1% of illness resulted in time loss of ≥ 1 day. In over 50% of illnesses, symptoms were present for ≥ 1 day before being reported to the team physician. To date, there are only a few studies where the true incidence of illness (illness per 1000 athlete days) in elite athletes during tournaments has been reported. This makes comparison to other studies where incidence is measured per 1000 athletes difficult.

As this tournament appears to be associated with a high incidence of illness, the aim of this dissertation was to explore the intrinsic risk factors associated with illness in eight of the 14 Super Rugby teams (average squad size of 30 players) during the 16-week 2010 Super Rugby

competition. These risk factors related to: a detailed training history; medication and supplement use; lifestyle factors, such as smoking and alcohol; a family history of asthma or allergies; immunization history; the player's medical history of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness.

An understanding of the epidemiology of illness and the possible intrinsic (player specific) risk factors contributing to illness in the two main systems affected by illness could assist medical personnel and coaching staff to minimize these risk factors in certain players or the team in general. This could result in a lower incidence of illness and hence a healthier squad of players for the coach to select from during the tournament.

Chapter 2

A review of the epidemiology and risk factors for illness in athletes participating in sport tournaments or competitions – a specific focus on Rugby Union

2.1. Introduction

In the modern-day sports calendar, competitions and tournaments are scheduled throughout the year in many countries and continents. The modern-day athlete frequently attends training camps away from their home country, and may participate in multiple national and international tournaments in a calendar year. The duration of these tournaments may vary from days to weeks. The physical and psychological demands on athletes are not only those related to training and competition, but in modern day sport include travel, living in confined conditions, sharing rooms, and exposure to differing environmental conditions. These demands may increase the risk of illness, which does not only increase the risk of medical complications during exercise but can also negatively affect athletic performance. As a result, there has been a growing recognition of the importance to protect the health of athletes. This has resulted in an increasing need for research to determine the risk of illness, patterns of illness and to identify the risk factors for illness. This information is essential to develop preventative measures to combat the risk of illness and protect the health of the athlete.

Rugby Union is one of the world's most physically demanding contact team sports. It is played in numerous countries around the world, and is also one of South Africa's most popular professional team sports. Repetitive body contact and impact during both matches and contact training sessions results in a well-documented high incidence of injuries in rugby, when compared to other sports. In a recent meta-analysis it was reported that match injury incidence rates in professional Rugby

Union are high in comparison with other team sports [8]. While the epidemiology and risk factors associated with rugby injuries have been well documented, similar data on illnesses in rugby players is not readily available. Indeed, we are aware of only two research studies where the focus has been on protecting the health of the rugby player [7, 9].

The Super Rugby tournament is a 16-week, annual tournament held in the southern hemisphere. In the 2010 Super 14 tournament, 14 international rugby teams took part in the tournament, which was held at different venues in South Africa, Australia and New Zealand and took place between February and May 2010. This annual Super Rugby competition is unique in that it is played over a long period of time (16 weeks) and it is held in 3 different countries. Therefore, unlike most other sports tournaments that are normally held in one country, at a single venue and over a shorter period of time, this tournament requires frequent international travel across multiple time zones for a period over a number of weeks. The exposure to a number of foreign destinations results in players being exposed to different allergens and pathogenic organisms, not to mention climatic changes, environmental conditions and differing diets. The effect that traveling across different time zones may have on illness risk in players has been studied [10].

The focus of this review is to describe the epidemiology of illness in athletes during various sports tournaments, followed by a specific focus on rugby, where these data are available. The review will then explore the risk factors that are associated with illness in athletes participating in sports tournaments.

2.2. Definitions and terminology

For the purposes of this review and this dissertation, standardized definitions and epidemiological terms, which have been used in other studies to express the burden of illness in athletes participating in competitions or tournaments, will be used as follows:

- *Illness*: An illness is defined as ‘any non-trauma related symptom or sign presenting in a player that required medical attention from the team physician on a specific day’ [7]. A repeat illness is defined as ‘any illness in the same player with the same final diagnostic code that was recorded

within 7 days' [7], and a time-loss illness is defined as 'an illness resulting in one or more lost training or match days' [7].- *Incidence*: The incidence of illness is defined as the number of illnesses reported per 1000 player days [11] [12] [13].

- *Incidence Proportion (IP)*: The incidence proportion is defined as the proportion of athletes reporting an illness during a tournament. This can be expressed as % athletes with illness or athletes with illness per 1000 athletes at the tournament [14] [15] [16] [17] [18] [19] [20].

- *Prevalence*: The prevalence is defined as the percentage of a population that is affected with a particular illness at a given time.

2.3. Epidemiology of all illnesses in elite athletes during tournaments

Until recently, the epidemiology and nature of medical illness in elite athletes has not been well studied. However, the International Olympic Committee (IOC) [2] and other sporting bodies, have increasingly recognized that illness is an important component of athlete medical care. In recent years, there have been more studies documenting the incidence and risk factors for illness in athletes participating in tournaments and competitions. Protection of the health of the athlete is now recognized as a very important component of holistic athlete care, and since 2007, the International Olympic Committee (IOC) has been developing various programs for the prevention of injuries and diseases in high level and recreational sports. This development is also taking place within International Federations (IFs) such as the Fédération Internationale de Football Association (FIFA), the International Ice Hockey Federation (IIHF), the International Association of Athletics Federations (IAAF) and the Federation Internationale de Natation Aquatics (FINA), as well as with renowned research institutions worldwide [3]. In the majority of the recently published studies, illness has been reported as an illness proportion (IP) rather than a true incidence (per 1000 athlete days of exposure) of illness.

In one of the earliest prospective studies, newly incurred illnesses were recorded at the 2009 International Association of Athletics Federation (IAAF) World Championship. In this study, the IP of illness was reported as 68.2 per 1000 registered athletes [16]. This was comparable to a

prospective study conducted during the 2011 Daegu IAAF Championship, where the IP was 68.1 illnesses per 1000 registered athletes [15]. These IP's are similar to those reported during the 2009 Federation Internationale de Natation Aquatics (FINA) competition (70.0 per 1000 registered athletes) [14], the London 2012 Summer Olympic Games (71.7 per 1000 registered athletes) [17] as well as the 2010 Winter Olympics (72.1 per 1000 registered athletes) [19]. However, in the 18-day 2014 Sochi Winter Olympic Games the IP was higher (89 per 1000 registered athletes) [20], and this was even higher at the second Asian Beach Games involving 14 different beach sports, where the incidence of illness was reported as 104.2 per 1000 registered athletes [18]. It should be noted that a significant limitation of reporting IP only in tournaments is that the length of the tournament (exposure days) can affect the IP. Therefore, reporting the incidence per 1000 athlete day exposure is more accurate, and allows for a true comparison between the incidences of illness in tournaments.

To date, there are only a few studies where the true incidence of illness (illness per 1000 athlete days) in elite athletes during tournaments has been reported. The true incidence of illness was first reported during the 2-week 2009 Confederations Cup Football tournament. In this study the incidence of illness was 16.9/1000 player days [13]. This was followed by a study conducted during the 4-week 2010 Federation Internationale de Football Association (FIFA) World Cup tournament where the incidence of illness was reported as 7.7/1000 player days [11]. At the 2012 Summer Paralympic Games, the incidence of illness was also studied. In this population of athletes the incidence of illness was reported as 12.8 per 1000 athlete days [12].

Therefore, it can be deduced that the incidence of illness in elite athletes is clinically significant, and warrants closer detection, monitoring, reporting and management. Illness plays a significant role in the performance of an athlete in- and out-of- competition and presents an important challenge to the medical team and the coaching staff alike.

It was noted in all of the illness studies documented above, that the most common system affected by illness was the respiratory system, followed by the digestive system [14] [16] [19] [15] [17]

[20] [18] [11] [12] [21]. The epidemiology of illness in these two systems will be examined in further detail in this literature review, and this dissertation.

2.4. Epidemiology of all illness in rugby players participating in a tournament

The epidemiology of illness in Rugby Union players during a season or during a competition has not been well studied [7]. In a review of the literature, only two studies on the epidemiology of illness in rugby players could be identified. In the first study, the incidence of illness in a group of 30 rugby players was documented over a 48-week period [9]. The main results were that 123 upper respiratory infections (URI) were recorded (incidence of four URI episodes per player over the period) and 25 digestive system complaints were recorded (0.8 per player over the period).

In a more recent study during the 16-week 2010 Super 14 Rugby tournament, the incidence of illness (per 1000 player days) was reported. Unlike other tournaments, which typically take place in one venue or in one country, this tournament is unique in that a) players travelled between South Africa, New Zealand and Australia over a 16-week period [7], b) the tournament is characterized by periods of play in the home country and periods of playing abroad where time zone differences vary from 2-11 hours [10], c) this tournament is an event that is characterized by very high intensity international standard rugby games [7] on 15 weekends over the 16-week period, with an addition of 3-5 training sessions per week. The tournament is also longer than most tournaments. The incidence of illness during this tournament was 20.7/1000 player days (95% CI 18.5 to 23.5), and this was higher when compared with the incidence of illness reported in the 2009 Confederation Cup football tournament (16.9/1000 player days) [13], the 2010 FIFA World Cup study in football players (7.7/1000 player days) [11] and during the 2012 London Paralympic Games (12.8 per 1000 athlete days) [12].

The reasons for this higher incidence of illness [7] could be attributed to a number of different factors including the following: a possible difference in risk of illness in different sports, a different pre-tournament player illness profile; travel differences (e.g. north-south vs. east-west crossing time zones) during the tournaments; exposure to different allergens or strains of

pathogenic organisms; differing environmental conditions (temperature, humidity, pollution); and variation in diets.

In both the studies in rugby players, the pattern of illness was similar. In the Super Rugby study, the most frequent illness was in the respiratory system (30.9%) (6.4: 95% CI 5.5 to 7.3) followed by the digestive system (27.5%) (5.6: 95% CI 4.9 to 6.6%) [7]. In this study, infection was recorded as the most common diagnosis, and infections accounted for 54% of all illness. These data are very similar to data on the pattern of illness in other individual and multi-coded tournaments. In all these studies, illness patterns are very consistent and show a high incidence of respiratory tract and gastrointestinal tract illness [14] [11] [19] [16]. Therefore, the epidemiology of illness in these two main systems will now be reviewed in more detail.

2.5. Epidemiology of illness in elite athletes during tournaments by system affected

As mentioned, respiratory and digestive system illnesses were consistently reported as the most common and second most common illnesses during sports tournaments.

2.5.1. Epidemiology of respiratory illness in elite athletes during tournaments

Elite athletes frequently report respiratory symptoms. Symptoms suggestive of Upper Respiratory Tract Infection (URTI) are responsible for 30 to 40% of visits to sports medicine clinics by elite athletes [22]. Evidence from several cross-sectional and prospective studies suggests that many elite and highly trained athletes experience more common colds or URTI than recreational athletes [23-25]. Athletes, especially in team sports, could be at a higher risk of illness and this could be due to factors such as the amount of time spent with each other in close proximity, the travel to different climates [10], and the potential temporary suppression in immune system function after high intensity exercise.

Acute upper respiratory tract (URT) illness was consistently reported as the most common medical condition reported at both the Summer and Winter Olympic Games [17, 19, 20, 24, 26],

and infection was ranked as the leading cause of respiratory tract illness [7, 12] [19, 20] [27] [28]. The impact of URI on selected pulmonary, cardiac and skeletal muscle functions may lead to illness complications and protracted courses of URI in athletes. Sport performance during illness may also decline [29]. Although there has been substantial research in the field of exercise immunology and infection during the last two decades, the actual pathogenic causes of symptoms of upper respiratory illness in athletes have not been clearly elucidated [30].

The incidence of illness during the 2010 Vancouver Winter Olympics was 72.1 illnesses per 1000 athletes, and of these illnesses, 62.3% affected the respiratory system [19]. The majority (63.8%) of these illnesses were as a result of infection. A study conducted during the 2010 FIFA World Cup reported 135 illnesses per 1000 players, with the majority of illnesses affecting the respiratory system (40.4%) and the most frequent diagnosis being acute upper respiratory tract infection (31.3%) [11]. Again, the cause of most illnesses was reported as infection in the majority of cases (60.6% of all illness).

In the 2010 Super 14 Rugby study, the most common system affected was also the respiratory system (30.9%), with the most common cause of illness being infection (58.7%) [7]. Of these, 15.9% were diagnosed specifically as acute Upper Respiratory Tract Infection (URTI). Similar data were reported in the 2009 FINA aquatics World Championships, where 50.3% of the 184 acute illnesses were of the respiratory system with infection most frequently classified as the cause (49.2%) [14]. At the London 2012 Summer Olympic Games it was documented that respiratory system illness was common (41% of the 310 reported illnesses) with the most common cause reported as infection (46%) [17]. These findings are also consistent with prevalence data from previous Olympic Games held in 1996, 2000 and 2004 [17, 31, 32].

In two studies in athletics, similar data were reported. The 2009 IAAF World Athletics Championships reported 135 illnesses with upper respiratory tract infection ranking as the most common condition at 30.4%, and infection the most frequent cause (32.6%) [16]. Similarly, the Daegu 2011 IAAF Championships study reported 126 illnesses with more than a third (38.9%) affecting the upper respiratory tract (including ear, nose and throat) [15]. Again, infection was the

most commonly reported cause at 27.8%. When reviewing a different sporting code, that of elite yacht racing, again it was consistently reported that URTI accounted for most illness related conditions (40%), which also accounted for most days absent from sailing (61%) and training (57%) [27].

In a 5-month prospective surveillance study conducted at the Australian Institute of Sport (AIS) on 32 elite and 31 recreationally competitive triathletes and cyclists, and 20 sedentary controls, it was reported that pathogens were isolated in fewer than 30% of URI cases [30]. Almost three quarters of the participants who reported an upper respiratory illness (URI) episode tested negative for detectable infectious agents by microscopy, culture, Polymerase Chain Reaction (PCR), and serological testing [30]. The authors concluded that further study is required to uncover the causes of unidentified but symptomatic URI in athletes.

Despite the consistent evidence that there is a high incidence of respiratory tract illness in athletes during tournaments, there are minimal data on the risk factors for Respiratory Tract Illness (RTI) in these athletes. There is a clear need for better understanding of the aetiology and risk factors of URTI in elite athletes, and of the diagnostic and treatment difficulties faced by physicians who deal with athletes presenting with upper respiratory symptoms during periods of intensive training and competition [30]. It is the loss of training and playing days that will be important to coaches and players alike. Being the most prevalent illness, it is therefore imperative that specific preventative measures be implemented to minimize the athlete's risk of developing a respiratory system illness. The most effective way of attempting this is to continue to research the aetiology and risk factors of such illnesses in athletes.

2.5.2. Epidemiology of digestive system illnesses in elite athletes during tournaments

There are some data from several epidemiological studies that digestive system illness is also common in athletes, and poses a major threat, not only to athlete's performance, but also to the spread of infection amongst team members. The implications of this can be widespread especially

when considering team sports. Digestive system illness consistently ranks as the second most common system affected by illness in elite athletes [6, 7, 11, 12, 14, 15, 19].

In a prospective study of illness during the 2010 Super 14 Rugby Union tournament, the second most commonly affected system was the digestive system (27.5%) [7]. Furthermore, the most common specific diagnosis was that of gastroenteritis 19.8% (infective and non-infective). Digestive tract illness, more specifically gastroenteritis, resulted in the most time-loss illnesses (47.3%) [7]. This was also documented in an analysis of 126 illnesses incurred during the 2011 Daegu IAAF Championships, where gastroenteritis again was recorded as the leading cause of time-loss illnesses (6 out of 23 illness episodes; 26.1%) [15].

The digestive system was the most commonly affected system during the 2013 FINA World Championships [33]. In a prospective study of newly incurred illnesses in 2592 athletes competing at the 2009 FINA World Championships (aquatics), almost a fifth of all 184 illnesses reported affected the digestive system (19.9%)[14]. This is similar to findings from a prospective study using data from the 2010 FIFA World Cup, which reported 99 illnesses in the 89 football players, of which 26 illness episodes (26.3%) related to the digestive system. The second most common diagnosis was gastroenteritis (21.2%)[11]. It has also been documented in an illness surveillance study of 2567 elite athletes across different sporting codes at the 2010 Winter Olympic Games, that 20% of illness was in the digestive system (36 out of 185 illnesses) [19]. An IP of 20% of Travellers' Diarrhoea (TD) was also reported by Team England during the Youth Commonwealth Games in India in 2008 [34].

With the improved fitness and conditioning of athletes, the most common reason to miss training or competition, whilst abroad, is illness; especially Traveller's Diarrhoea (TD) with an athlete potentially unable to compete for up to 3 days and after that not performing at an optimum level for several more days [5]. In a report detailing the most pertinent medical issues related to the travelling athlete to the 1998 Malaysian Commonwealth Games, it was suggested that most cases of Traveller's Diarrhoea (TD) are due to non-viral pathogens such as enterotoxigenic Escherichia Coli, Salmonella, Shigella, Campylobacter and Giardia Lamblia [35]. A high incidence of

Traveller's Diarrhea was reported in hockey players travelling to South Africa, India and Malaysia where it was suggested that not only food, but unclean water both in the showers and on the pitch resulted in digestive system illness [5].

The incidence (illnesses per athlete day exposure) of digestive system illness at the 2012 London Paralympic Games was 1.90/1000 athlete days [12]. This was equivalent to an Incidence Proportion (IP) (percentage of athletes with illness) of 14.5% of all illnesses during both the pre-competition (3 days) and competition period (11 days). This study was a component of a large prospective cohort study on the epidemiology of illness in 3565 elite Paralympic athletes at the 2012 Games [12]. A slightly higher incidence rate (5.2/1000 athlete days) of digestive system illness was recorded in the Polish team at the same Games [6]. This same team (Polish team) documented an IR of 3.1/1000 athlete days at the 2008 Beijing Paralympic Games.

In summary, digestive system illness also commonly affects elite athletes and there is a need to determine potential risk factors for digestive system illness, which may then identify measures to reduce the risk and improve treatment.

2.6. Risk factors for illness in elite athletes during tournaments

Risk factors for illness can be classified as extrinsic risk factors and intrinsic risk factors.

Extrinsic risk factors refer to factors that are outside of the control of the player, for example hotels or environmental conditions. Intrinsic risk factors are factors that are inherent to a player, and may be modifiable (for example training and nutrition), or non-modifiable (age and sex).

While there are numerous studies and scholarly articles describing the extrinsic and intrinsic risk factors related to risk of sports injuries, there are very few epidemiological studies to determine the risk factors for illness in elite athletes, or in sport in general. In the next section, the extrinsic and intrinsic risk factors for illness in athletes will be reviewed.

2.6.1. Extrinsic risk factors for illness in athletes

2.6.1.1. International travel

A high proportion of international travellers experience health problems [36]. The unprecedented scale and speed of contemporary international travel means that ever-increasing numbers of travellers are exposed to unfamiliar environments and other hazards [37]. Air travel, cramped living conditions, changes in diet, differing environmental conditions (such as temperature, humidity, atmospheric pollution and altitude), exposure to different allergens and pathogens as well as high training and competition loads during travelling may all contribute to an increased risk of illness in the travelling athlete [35].

In modern sport, elite athletes are frequently required to travel long distances for major competitions [4]. There is some evidence that international travel predisposes individuals to common infections including influenza and gastro-intestinal illness [38]. However, there are few published studies reporting illness in travelling athletes, and indeed few prospective studies in the travel medicine literature for comparison. More research is needed to determine the precise incidence of illness in travelling athletes from other sporting codes, other tournaments, different travel durations, travel destinations and travel direction (e.g., north–south compared with east–west) [10]. International travel often places athletes at a greater risk of failing to meet their specific nutrition goals or succumbing to illness, at a time when the demands or outcomes of performance are of greatest importance [39].

In one prospective cohort study, conducted over a 16-week period during the 2010 Super 14 Rugby Union tournament, it was reported that international travel to a foreign destination greater than 5-hours time zone difference from the home country was associated with a significant increase (2-3 times) in the incidence of all illness [10]. Players travelled to South Africa, New Zealand or Australia from their home country (which was one of the 3 countries mentioned), at least once and sometimes twice or even three times during the 16 weeks. It was further reported that the incidence of illness was not affected by the direction of international travel (easterly or westerly direction) [10]. Furthermore, travelling back to the home country was not associated with an increased incidence of illness compared with baseline (before travel).

It was also suggested by the authors of this particular study that factors such as close contact with fellow air travellers, drying of respiratory epithelium and exposure to re-circulated air [10], may not be significant factors in the aetiology of respiratory system illness. The reason for this conclusion was that a similar incidence of respiratory system illness was documented in both directions of travel; however there was only an increased incidence when the athletes departed from their home country. This was the first prospective cohort study to determine the effect of international travel on the incidence of illness in elite athletes participating in a prolonged tournament.

2.6.1.2. Athlete accommodation

During sport competitions, it is common practice that players or athletes share rooms in hotels or Olympic villages or at training camps or venues, especially in team sports. Living in such close proximity to one another is a possible risk factor for the spread of illness. In a study of over 300 sailors during the amateur British Telecom Round the World Yacht Race which took place between 1996-1997, it was reported that respiratory illness, particularly upper respiratory viral type infections, were the third most common and may have spread as result of close quarter living conditions [40].

In a study that documented the efficacy of an illness prevention program for Norwegian athletes during the 2010 Vancouver Winter Olympics, one of the interventional strategies implemented was that athletes with a heavy competition load, or with a susceptibility to respiratory tract infections and airway problems, were accommodated for the most part in single hotel rooms during the pre-Olympic competition period as well as during the Games. This was a strategy to minimize the risk of exposure to contagious diseases and exacerbations of asthma and allergy [41].

2.6.1.3. Regular close contact with team members

In team sports, athletes may spend a significant amount of time together in close contact. It is reported in the 2010 Super 14 Rugby study, that it is common for all Super Rugby franchises to have their own training base where players are in close proximity to one another for 4-6 hours per day for about 4 days per week [7]. At these facilities players may share meals together and make use of communal shower and ablution facilities. All these factors could facilitate the spread of illnesses (both air-borne and by contact). It has been suggested that when athletes are members of sporting teams housed together, any team member who is developing a respiratory tract infection should be isolated as far as is practical [42]. The sharing of water bottles and water cups during drinks breaks in training sessions or matches also has the potential to spread infection.

2.6.1.4. Increased duration of a competition or tournament

Research to date on the incidence of illness in elite athletes and sports events has some limitations. These limitations include the reporting of an IP (percentage of athletes with illness) that does not allow for comparison of illness rates in competitions of different durations [12]. Therefore, it was suggested that the use of incidence rates (IR; illnesses per exposure, e.g., 1000 player days) would be a more preferable methodology.

In a prospective cohort study of the 2010 Super 14 Rugby Union tournament it was documented that the longer duration of the tournament (16 weeks) could be a possible factor resulting in the higher incidence of illness (20.7/1000 player days) [7] when compared to, for example, a prospective study of the 2 week long 2009 Confederations Cup Football tournament (16.9/1000 player days) and the 4 week FIFA 2010 World Cup (7.7/1000 player days) [7].

An illness was reported in 10.9% of athletes (IP: percentage of athletes with illness) in the 11-day competition period of the London 2012 Paralympic Games [12]. This was less than the 4 week long 2010 FIFA World Cup football (12%) [11] and remarkably lower than the 16-week Super 14 Rugby tournament (75%) [7]. However, this comparison was limited owing to the different

durations of competition [12]. The more preferable methodology for comparison, illness rate (IR), recorded a rate of 12.8 for the Paralympic study [12] which, with this measurement, was now higher than the 2010 FIFA World Cup (7.7).

For purposes of future illness studies on elite athletes, it is suggested that incidence of illness be reported as per 1000 athlete days in order to make comparisons with previous studies more appropriate.

2.6.1.5. Environmental factors (temperature, humidity, pollution)

It has been suggested that challenging environmental conditions, including heat and humidity, cold, and altitude, may pose particular risks to the health of Olympic and other high-level athletes [43]. The importance of environmental factors as a risk factor for illness cannot be underestimated. In a study conducted on the 2009 IAAF Athletics World Championships, it was concluded that most illnesses were caused by infection of the respiratory tract or were environmentally related, and that preventive interventions should focus on decreasing the risk of transmission, appropriate event scheduling, and heat acclimatization [16]. This was similar to the conclusion of the FIFA 2010 Football World Cup study, which stated that prevention of illness should focus on reducing the risk of infections by considering the common modes of transmission and environmental conditions [11]. Environmental conditions were also suggested as a possible factor in the recording of a higher incidence of illness during the 2010 Super Rugby study when compared to the 2010 FIFA World Cup football [7].

Environmental conditions during an international competition may be significantly different to those normally experienced by an athlete in his/her country of residence. For example, athletes residing in more temperate parts of the world may find themselves competing in cold conditions in Europe. They may live at sea level and then partake in a competition at altitude. Humidity may be a factor as well as air pollution. A number of individual factors (e.g. experience, recent health history status, fitness, acclimatization, physical and psychological make-up, nutritional and hydration status and sweat loss rate) each may play a key role in the athlete's capacity to

adequately adapt to, and safely tolerate, new and demanding environments [43]. In several of the studies that were reviewed, environmental conditions are listed as a possible cause of illness [7, 11, 13-15].

Elite athletes, particularly those engaged in endurance sports and those chronically exposed to airborne pollutants, irritants or allergens, are at increased risk for upper and lower airway dysfunction [42]. Elite athletes are repeatedly exposed to cold air during winter training and competitions, which may expose them to an increased risk for upper respiratory tract infections [19] [44]. In the 2010 Winter Olympics in Vancouver, a total of 58% of respiratory illnesses were suffered by Nordic skiing and skating athletes [19]. Regular changes in temperature and humidity, such as going from inside athlete accommodation and other living quarters to outside, has also been cited to contribute to the high incidence of respiratory illness [30]. In a prospective study of newly incurred illnesses in 1851 athletes at the Daegu 2011 Athletics World Championships, it was recorded that 13.5% of illnesses were attributed to environmental factors [15]. This was the third most common cause after infection (27.8%) and exercise-induced causes (17.5%). In this study, it was suggested that temperature and humidity changes between athletes' accommodation, outdoor, warm-up area, call room or stadium could also play a role in the high incidence of URTI. Gastroenteritis and dehydration were also commonly reported during elite Athletics Championships (around 10% and 12%–17%, respectively) [16]. Climatic conditions, nutritional changes and overcrowding were suggested as possible predisposing factors.

Environmental factors for illness were the second most common cause recorded in a prospective study of newly incurred illnesses of 2592 athletes at the 2009 FINA World Championships (aquatics). Environmental factors was reported as a cause of 27.6% of all illnesses, second only to infection (49.2%) [14], and was also documented as the second most common cause of illness within the 32 finalist teams at the 2010 FIFA World Cup. Again, environmental factors were reported as the cause of 23.2% of illnesses [11].

Prior to the 2008 Beijing Olympic Games, there had been extensive debates regarding air pollution and its influence on athlete health and/or performance [45]. The Czech Olympic team

attempted to quantify this risk by placing devices on the balconies of athlete accommodation in the Olympic Village which measured ambient temperature, relative humidity and particulate matter with aerodynamic diameter below 10 μm (PM10) during and shortly before the Games between August 3 and 24, 2008. The results showed that air quality did not result in increased health risks for the athletes [45].

Combustion-related pollutants such as nitrogen and sulphur oxides, the ammonium ion, organic aerosols, particulate matter (PM) and ozone are of concern. Inhaled PM can be causal to oxidative stress-related airway and vascular injury [46]. Although there is ample evidence of short-term and long-term exposure affecting the respiratory and the cardiovascular systems, little data are available demonstrating the effects of air pollution inhalation on athlete performance [47], and less so on infection related risks. However, it has been suggested that acute exposure to mixed exhaust aerosols during exercise can cause decreases in lung and vascular function in both healthy and asthmatic subjects [46]. Similarly, only 30 minutes of exposure to high-PM ($>60\,000$ particles/ cm^3) ambient air during exercise causes a small but significant decrease in lung function in non-asthmatics [48]. How this translates into infection or illness related risks to the athlete requires further study.

2.6.2. Intrinsic risk factors for illness in athletes

2.6.2.1. *Female sex*

In athletes participating at the 2009 IAAF World Athletics Championships, a significantly higher incidence proportion (IP) of illness was reported in female athletes compared to their male counterparts (83.5 vs. 55.5 illnesses per 1000 athletes), especially for gastro-intestinal illness (16.7 \pm 8.5 vs. 6.5 \pm 4.8 illness per 1000 athletes) [19] [16]. Similarly, in the 2012 Summer Olympic Games in London, women suffered 60% more illnesses than men (86.0 vs. 53.3 per 1000 athletes) [17]. Again in the 2014 Sochi Winter Olympic Games, women suffered 50% more illnesses than men [20].

A study conducted at the first Winter Youth Olympic Games in Innsbruck (Austria), reported that 11% of female and 6% of male athletes suffered from an illness, resulting in an incidence of 112.8 illnesses per 1000 female athletes and 61.4 illnesses per 1000 male athletes, respectively [49]. In an observational prospective cohort study conducted on the Great Britain Olympic Team athletes (TeamGB) at the 2014 Sochi Winter Olympic Games, it was reported that there were more illnesses sustained by female athletes when compared with male athletes. In this study, 30% of female vs. 9% of male TeamGB athletes were affected by illness - however, this was not statistically significant (RR 3.33 (95% CI 1.58 to 7.01); $p=0.075$) [28]. Furthermore, female athletes who sustained illnesses during the Games were significantly older than their non-ill female counterparts (ill: 28.4 years, 3.7 SD; non-ill: 24.5 years, 3.6 SD; $p=0.026$) [28].

However, a prospective cohort study of 3565 athletes competing in the London 2012 Paralympic Games documented that sex was not associated with an increased risk of illness [12]. This was consistent with the findings on gender differences in illness incidence in the 2013 FINA World Championships [33]. Therefore, there is some evidence that females may be at a higher risk for illness during sports tournaments, but this requires further investigation.

2.6.2.2. Older age

In athletes participating at the 2009 IAAF World Athletics Championships, the number of illnesses increased significantly with age (≤ 20 years: 45.7 ± 29.8 , 21–25 years: 58.8 ± 16.5 ; 26–30 years: 70.3 ± 20.5 ; ≥ 30 years: 103.3 ± 36.4 illnesses per 1000 athletes) [16]. An IP of 6.82 % was documented [16]. In a prospective cohort study of the 5-day 2013 European Youth Olympic Festival (EYOF), a lower IP of illness (2.02 %) was reported in younger athletes aged between 13-18 years [50]. This study was the first multisport surveillance study on illnesses during the EYOF or any other summer Games organized for youth elite athletes. For that reason, it was difficult to compare the present data with similar studies. However, a prospective cohort study of 3565 athletes competing in the London 2012 Paralympic Games, documented that older age was not associated with an increased risk of illness [12].

More research is required to investigate whether the lower incidence reported could be due to the younger age of athletes. Interestingly, most of the illnesses affected the gastrointestinal system, while in other studies with adults, it is the incidence of respiratory system illness which is high [50]. Again, further prospective studies are required to ascertain whether this is an age related phenomenon or an incidental finding possibly related to other illness risk factors.

2.6.2.3. Body Mass Index (BMI)

Body Mass Index (BMI) is a measure of overweight or obesity and is calculated from the mass (weight) and height of an individual. In the general population it is regarded as an important measure of health risk for diseases such as cardiovascular disease and diabetes. In most athletes who participate in sports where an increase in body mass may be an advantage, such as rugby or weightlifting, BMI is regarded as an inaccurate measure of body composition. This is mostly as a result of an increase in muscle mass which would group the athlete's BMI in the 'overweight' category. On the opposite end of the spectrum, athletes in sports where leanness is an advantage such as gymnastics would have a low BMI. A more accurate measure in sports is considered to be body composition (BC). This can be measured in a number of ways for example, using skinfolds, bioelectrical impedance or dual-energy x-ray absorptiometry (DXA) scanning.

In a review of the published literature, there are, to our knowledge, no studies that have explored the relationship between BMI (or BC) and illness in elite athletes. This could be a subject of future studies, especially in sports where leanness is an important performance-determining factor as it has been suggested that in many cases it can result in illness when training and competition is continued at high levels [51] [52].

2.6.2.4. Training factors

It is well documented that both acute exercise bouts and regular training have various effects on the immune system. An acute bout of heavy exercise induces immune system responses, which are similar to those induced by infection [53]. A comprehensive review of the effects of both an acute bout of exercise and the effects of prolonged training on the immune system is beyond the scope of this review chapter in the dissertation. Therefore, the potential negative effects of exercise on the immune system, and the implication of training as a risk factor for illness, will only be summarized.

The immune system is divided into the innate immune system, and the adaptive immune system. The innate immune system and the adaptive immune system each comprise both humoral and cell-mediated components. Several effects of exercise on both these systems and components of the two systems have been studied and documented. It has been suggested that the innate immune system undergoes changes with an enhancement of natural killer cell activity (NKCA) and a suppression of neutrophil function [1]. A release of white blood cells causing a temporary leukocytosis after heavy training has been reported [54]. Low concentrations of lymphocytes, suppressed natural immunity, suppressed lymphocyte proliferation, and suppressed levels of secretory immunoglobulin A (sIgA) in saliva are found simultaneously with high levels of circulating pro-inflammatory and anti-inflammatory cytokines [55]. Training at an intense level can result in a chronic suppression of sIgA levels (measured in saliva) [56] which provides first-line-of-defense protection against a range of pathogens at mucosal surfaces particularly those lining the upper respiratory tract. This translates into an increased risk of URTI in athletes [57]. This period of an altered immune state following intense or prolonged exercise is referred to as the 'open window'. During this 'open window', which may last between 3 and 72 hours, viruses and bacteria may proliferate increasing the risk of subclinical and clinical infection [1].

It is now generally accepted that strenuous exhausting exercise can increase susceptibility to viral infection during the following days or weeks [58]. Although moderate intensity exercise can benefit health, high intensity and prolonged exercise may have the opposite effect [59]. The demanding training programs of many elite athletes may suppress the immune system, and thereby increase susceptibility to infections [23]. Periods of intensified training lasting for one week or more, frequently observed over the course of a competitive season, may result in chronically impaired immune function and increased infection risk [60, 61].

A review of the literature shows that upper respiratory tract infections and skin infections are more prevalent in elite level athletes than in the general population, particularly during periods of intensive training [62]. More recently, it has been suggested that intense exercise training appears to result in an increase in airway inflammatory cells [63]. Therefore, ongoing research is required to determine whether the high incidence of URTI recorded is in fact due to infection or perhaps an inflammatory response as a result of other causes. It has been shown that endurance athletes from a variety of sports including orienteering, rowing, swimming and distance running have a documented increase in the incidence of URTI symptoms, possibly linked to periods of intense training, increased training volume, or periods of competition [62, 64]. However, increases in airway neutrophils, eosinophils and lymphocytes have been described under resting conditions in endurance sports, swimmers and cross-country skiers [63].

Finally it is important to note that athletes who experience recurrent infections during periods of maximum training or competition stress may suffer from the overtraining syndrome (OTS) [65]. This is a condition seen in athletes and is characterized by prolonged fatigue and under performance, following a period of heavy training or competition. A medical illness, such as infectious mononucleosis, needs to be excluded as a primary cause in order for the diagnosis of OTS to be made. However, an increased susceptibility to infections resulting in illness, fatigue and malaise may be secondary to overtraining.

2.6.2.5. Recent close contact with an individual suffering from an illness

Close contacts can be defined as individuals who had sustained unprotected exposure to a confirmed case for a significant duration of time (e.g. more than 1 h) and within a close proximity of 2 m [66]. The reverse would also apply, where an athlete would be exposed to an individual (close contact) who is suffering from an illness. It has been suggested that athletes should endeavor to avoid contact with persons showing signs of upper airway infections, particularly while undertaking intensive training schedules and before major competitions [42]. Despite close contact being suggested as a risk factor for illness in the general population, there are no published studies where this has been documented as a risk factor for illness in athletes, and therefore this is an important area for future studies.

2.6.2.6. *History of allergy or asthma*

The three principal disorders which correlate allergic diseases with exercise and the practice of sport are exercise-induced asthma (EIA), exercise-induced anaphylaxis (EIA_n) and exercise-induced urticaria (EIU). These will not be discussed in detail in this literature review, but the relationship between these allergic diseases and an increased risk of illness to the athlete will be briefly reviewed.

It has been suggested that there is a relationship between the risk of a viral infection and allergy, [67]. In a study of elite athletes (49 speed and power athletes, 71 long distance runners and 42 swimmers), it was recorded that atopy, diagnosed using skin prick test results, was found in 48% (77 of 162) of the athletes studied and in 36% (16 of 45) of the control subjects (not significant). Furthermore, clinical pollen allergy (positive skin test reaction to pollen and symptoms of rhinoconjunctivitis) was significantly ($p = 0.037$) more common in the athletes than in control subjects [68]. How this translates in to infection risk has not been specifically studied. However, it has been suggested that allergy frequently contributes to the development and manifestation of respiratory problems in the athlete [69]. It has been documented that there is a marked decrease of salivary IgA levels in athletes during and after a training session [56]. This could be a predictive marker of infectious risk for athletes [70], and also for allergic patients performing various physical activities [67]. Studies concerning the effects of exercise on the immune system may also yield further data and contributions to studies on allergy and sports [67].

It is noted that asthma is more common in highly trained athletes than in control subjects [68]. In one study it was found that current asthma (current asthmatic symptoms and increased bronchial responsiveness) was observed in 14% (22 of 162) of the athletes and in 2% (1 of 45) of the control subjects ($p = 0.041$). Furthermore, total asthma (current asthmatic symptoms and increased bronchial responsiveness or physician-diagnosed asthma) was reported in 23% (37 of 162) of the athletes and in 4% (2 of 45) of the control subjects ($p = 0.0048$) [68].

Asthma is especially common in elite swimmers, but the risk of asthma is increased also in speed and power athletes as well as long-distance runners [71]. This study documented the occurrence (odds ratio) of current asthma as 5.49 in speed and power athletes, 2.88 in long-distance runners, and 10.8 in swimmers compared with control subjects. How this correlates with the incidence of

illness (respiratory system or other) was not studied. It has however, been suggested that athletes with asthma should consider having an annual influenza vaccination [42]. This suggests that asthma could be a risk factor for respiratory illness.

In summary, although there is some evidence that allergies are more common in athletes, there are little data linking a history of allergies to an increased risk of respiratory tract illness in athletes. This requires further study.

2.7.2.7. Medication use

The frequent use of medication and supplements by elite athletes across various sporting codes is well described in the literature. In a descriptive epidemiological study where 3 887 doping control forms from 12 International Association of Athletics Federations (IAAF) World Championships and 1 out-of-competitions season in track and field were analyzed, it was recorded that there were 6 523 nutritional supplements used by the athletes (1.7 per athlete) and 3 237 medications were used by the athletes (0.8 per athlete). Non-steroidal anti-inflammatory drugs (NSAIDs; 0.27 per athlete, n = 884) and respiratory drugs (0.21 per athlete, n = 682) were the most common [72]. How these findings correlated with infection risks in the athletes was not analyzed. In a review of published data from 10 men's, women's and male adolescent FIFA World Cups [73], it was again found that the most frequently prescribed medication was non-steroidal anti-inflammatory drugs (NSAID). This is consistent with several other studies reporting on medication use amongst athletes.

The association between medication and/or supplement use and illness in athletes, is not as well reported. In one study [16] one illness complaint was attributed to the use of medication. This was related to the digestive system. Furthermore, in 12 previous track and field Championships [72], 19.2% of participating athletes reported to have taken NSAIDs and 3.8% antibiotics. This led the authors to conclude that considering the frequent use of medication reported in the literature that more complaints, especially of the digestive system, as well as dehydration-related effects, could have been expected.

It is therefore an area of sports medicine that requires further research, especially considering the widespread use, and therefore the danger of returning positive doping control tests [72], as well as

the poor understanding of related side-effects by the athletes themselves and delays in tissue healing [73].

2.6.2.8. Nutritional factors/supplements

Scientific research has long shown that inadequate nutrition may contribute to impaired immunity and makes the individual more susceptible to infection [61, 74]. Recently, nutrition research has focused on the role of foods or specific food components in enhancing immune system responsiveness to challenges and thereby improving health and reducing disease risks [60]. Nutritional factors and the effect on illness risk are well studied in the general population. However, in the elite athletic population, the link between illness and specific nutritional deficiencies (including micronutrients) and the need for supplementation is broad, and research is ongoing. However, it has been suggested that inadequate or inappropriate nutrition can compound the negative influence of heavy exertion on immunocompetence [74].

To our knowledge, no studies have specifically examined the short-term and long-term risk of acute illness in groups of elite athletes using extreme dieting and DE (Disordered Eating) during their sports career [75]. It is likely that athletes who suffer from long-term LEA (low energy availability) may develop nutrient deficiencies (including anemia), chronic fatigue and increased risk of infections and illnesses, all of which have the potential to harm health and performance [75]. Energy availability is defined as the amount of ‘unused’ dietary energy remaining for all other metabolic processes after the energy cost of exercise training is subtracted from the daily energy intake [76]. Functional impairments associated with LEA include a greater prevalence of viral illnesses [77]. Screening for RED-S (Relative Energy Deficiency in Sport) can be undertaken as part of an annual periodic health examination and when an athlete presents with Disordered eating (De), weight loss and, amongst other symptoms, recurrent injuries and illnesses, and/or decreased performance /performance variability [78].

Immune function is also disturbed by substantial restrictions in intake of energy and protein as well as inadequate status of various micronutrients [79]. Training on a very low-fat diet (15% dietary fat) may be detrimental to exercise performance and leads to an overall compromised immune function due to a negative energy balance [80]. Similarly, exercising in a carbohydrate

depleted state may result in higher levels of stress hormones and an impaired immune function [61]. One study examined the nutritional and activity habits of 25 adolescent amateur swimmers in the United Kingdom. It was concluded that if a reduced susceptibility to illness was desired, the swimmers should seek to ensure that their dietary intake contained an optimized proportion of energy derived from macronutrients. They were also to ensure that enough foods containing fibre, vitamin A and selenium were consumed as these were found to be deficient when compared to Recommended Nutrient Intake values [81].

More recently, there has been substantial interest in the link between the immune system and antioxidants. Optimal antioxidant levels and immune function in athletes are not well described [79]. It has been suggested that a single bout of exercise causes a stress to the body's immune and antioxidant status. However, detecting a link between changes in nutritional status, decreases in concentration or activity of various immune system parameters, and the incidence of common illnesses such as upper respiratory tract infections is complicated. Further research is required to better identify this cause and effect relationship.

Convincing evidence that so-called 'immune-boosting' supplements, including high doses of antioxidant vitamins, glutamine, zinc, probiotics and Echinacea, prevent exercise-induced immune impairment is lacking [74]. It is however, of interest that antioxidant supplementation has been proposed as complimentary therapy for athletes exposed to air pollutants. In a study designed to identify whether acute lung function effects of ozone can be modulated by antioxidant vitamin supplementation, it was found that in a group of 26 heavily exercising amateur cyclists, a mixture of antioxidants (Vitamin C, E and beta carotene) conferred partial protection against ozone-mediated adverse effects [82].

In a more recent study, it was suggested that consuming 30-60 g carbohydrate per hour during sustained intensive exercise attenuates rises in stress hormones such as cortisol and appears to limit the degree of exercise-induced immune depression [74]. It has also been shown that when carbohydrates (>6% CHO solution-typically sports drinks) are frequently delivered during prolonged exercise maintains blood glucose levels and may help to attenuate exercise induced changes of stress hormone levels, leukocyte cell counts and cytokine changes[61].

2.6.2.9. Other factors

Other factors may also be related to an increased risk of illness but these have to-date not been studied in athletes participating in tournaments. These could include a family history of allergies, and lifestyle factors such as smoking and alcohol use. These and other risk factors would require further study.

2.7 Summary: Epidemiology and risk factors for illness in athletes

In summary, there is clear evidence from data in a number of prospective cohort studies that illness is common in athletes participating in tournaments. Furthermore, data from these studies show that respiratory tract and gastrointestinal tract are the two most common systems affected by illness in athletes. Despite these findings, there are very few well-conducted studies examining the relationship between specific extrinsic and intrinsic risk factors for illness in athletes. In this review, the risk factors (extrinsic and intrinsic) associated with illness in athletes and the level of evidence for these risk factors were explored and these risk factors, as well as the level of evidence for each risk factor, are summarized in Table 2.1

Table 2.1. A summary of extrinsic and intrinsic risk factors for illness in athletes (including level of evidence for risk factors)

	Risk Factor	Study details and references	Level of Evidence (I-IV)
EXTRINSIC RISK FACTORS	International travel	Prospective cohort study [10]	I
	Athlete accommodation	Expert opinion [40]	IV
	Regular close contact with team members	Descriptive case series in Norwegian athletes [28]	III
	Increased duration of competition or tournament	Prospective cohort study [7]	I
	Environmental factors	Expert opinion [15] [14] [11] original article [45] article [35]	IV
INTRINSIC RISK FACTORS	Female sex	Prospective cohort studies [16] [17] [20] [28]	I
	Older age	Prospective cohort study [16]	I
	Body Mass Index (BMI)	No data	
	High intensity and prolonged training	Systematic reviews [62] [64] [53, 60, 61].	II
	Recent close contact with and individual suffering from an illness	Expert opinion [42]	IV
	History of allergy or asthma	Expert opinion [69] [67]	IV
	Medication use	Expert opinion [16] [72]	IV
	Nutritional factors/supplements	Systematic review [81] [61, 80]	II

In summary, there are good data from one prospective cohort study indicating that international travel, and the duration of a tournament are extrinsic risk factors for illness in athletes. Athlete accommodation, close contact between athletes and environmental conditions are listed as extrinsic risk factors, but evidence is lacking and this requires further study. There is good data from a number of systematic reviews that prolonged and high intensity training, older age, and nutritional deficiencies are intrinsic risk factors for illness in athletes. Other intrinsic risk factors such as extremes of the BMI, recent close contact with infected fellow athletes, a history of allergic illness and medication use are listed by experts, but these require further study using prospective cohort study designs. The accurate documentation of these extrinsic and intrinsic risk factors for illness is the first step in designing interventions to reduce the risk of illness in athletes.

Chapter 3

Risk factors associated with illnesses during the 2010 Super Rugby tournament - a prospective cohort study involving 22676 player days

3.1. Introduction

The Super Rugby tournament is a 16-week, annual tournament held in the southern hemisphere. It was introduced in 1996 and was the first fully professional rugby tournament at the time involving 10 teams. Its popularity grew over the years and has now expanded to involve 15 teams from the southern hemisphere. The tournament is played over a 4-month period in the beginning half of the year between teams from South Africa, Australia and New Zealand. Teams play most weekends for the duration of the 16-week tournament. The competition is generally regarded as one of the most gruelling rugby competitions in the world, placing exceptional physical and emotional stresses on the players. Furthermore, teams have to travel across multiple time zones as matches are played in venues in all three countries, resulting in very demanding travel schedules and exposure of the athletes to different allergens and pathogenic organisms, not to mention climatic changes, environmental conditions and differing diets.

The incidence of illness in in Super Rugby was relatively high when compared to several other illness studies during tournaments or competitions [12] [11] [13]. Reference was made to the possible effects of a longer duration tournament, the demanding travel schedule and to various other possible causes. However, the specific player-factors that may predispose a player to illness were not explored and have not been explored in any studies to our knowledge.

Various risk factors may affect illness risk and they include the following: training history; medication and supplement use and lifestyle factors, such as smoking and alcohol; a family history of asthma or allergies; immunization history; the player's medical history of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness. However, to our knowledge, these risk factors have not been studied in a tournament setting.

Therefore, the aim of this study was to determine which intrinsic risk factors may be associated with increased risk of illness in rugby players during a 16-week Super Rugby tournament.

3.2. Methods

3.2.1. Type of study

This was a prospective cohort study involving 239 players from South Africa and New Zealand, over the 16-week duration of the 2010 Super 14 Rugby Union tournament.

3.2.2. Selection of participants

The UCT (University of Cape Town) Research Unit for Exercise Science and Sports Medicine conducted the study in conjunction with the South African Rugby Union (SARU). Research ethics approval was obtained from the University of Cape Town Health Sciences Research Ethics Committee (REC 008/2010) prior to the commencement of the tournament.

All the players from South Africa and New Zealand teams participating in the 2010 Super Rugby tournament were approached to participate in this study. Each team consisted of a squad size that varied between 28 and 36 players per team. Team physicians from South Africa and New Zealand were contacted and support and co-operation from the team's physicians was gained. Detailed information about all aspects of the study was explained to players through the team physicians. Each team physician explained all aspects of the study including benefits and potential risks and a detailed player information sheet was provided to the respective players in their team. Written informed consent was obtained from players in order to participate. Anonymity was insured by a system of coding that was employed anonymously for each player and team. An independent party assigned the codes and these were kept in a sealed envelope in safe storage until post-competition.

All 5 teams from South Africa and 3 out of 5 teams from New Zealand took part in the study. The total study population was 239 players from the 8 teams (Table 3.1).

Table 3.1. Demographic data for the study population (all players, teams and player position) Values are mean (SD)

		N° of players	Age (years)	Weight (kg)	Height (m)	Body Mass Index (kg/m²)
All players		239	25.1 (3.2)	102.2 (11.6)	186.7 (7.2)	29.3 (2.7)
Teams	1	28	24.9 (2.1)	105.0 (9.3)	186.1 (6.6)	30.3 (2.6)
	2	28	26.2 (3.3)	101.0 (12.2)	186.4 (7.5)	29.0 (2.4)
	3	34	25.5 (3.2)	100.1 (12.1)	187.4 (7.0)	28.5 (3.0)
	4	35	24.4 (3.3)	104.3 (9.1)	187.1 (7.0)	29.8 (2.3)
	5	14	25.8 (2.7)	105.1 (13.1)	186.1 (5.4)	30.3 (3.1)
	6	39	25.7 (3.8)	100.2 (12.5)	186.6 (8.1)	28.6 (3.0)
	7	31	25.4 (3.6)	104.7 (10.8)	187.5 (6.6)	29.7 (2.3)
	8	30	23.3 (2.7)	99.0 (13.4)	185.6 (8.3)	28.7 (2.9)

3.2.3. Pre-tournament medical data collection

All the players were requested, with the assistance of the team physician, to complete a player medical questionnaire in the 7 days before the tournament. The purpose of this questionnaire was to determine any possible risk factors that may be associated with the development of illness during the tournament. The questionnaire data included the following: training history in the 15 weeks prior to, and the 2 weeks prior to the commencement of the tournament, medication and supplement intake, lifestyle factors (including smoking and alcohol intake), a family history of asthma or allergies, player immunization history, history of asthma, allergies or recent flu-like illness and close contact with relatives/friends with flu-like illness prior to the tournament. These data were used to determine whether there were any risk factors associated with the development of any illness, and specifically respiratory illness and gastro-intestinal illness during the tournament.

3.2.4. Illness data collection during the tournament

Collection of data took place each day of competition, beginning 7 days before the first game the team played, and ending when each team played their final game. Each team physician completed

a daily "medical illness log" for every player. Booklets were supplied that contained daily illness report forms.

A medical illness was defined as “any non-trauma related symptom or sign presenting in a player that required medical attention from the team physician on a specific day”. An illness was clinically assessed by the respective physician and was then recorded on the daily report form. The daily report form contained information that would be similar to that which would normally be utilized in the clinical care of a player and included the following: presenting signs and symptoms, duration of symptoms (days), final clinical diagnosis, loss of training/match days and the suspected etiology of the illness (a list of common causative organisms was provided).

The physicians kept the booklets each day, and the completed booklets were only submitted to the research team at the conclusion of the tournament. There was 100% compliance in the return of all booklets. The central research office and the team physicians had regular contact during the tournament by either phone or email in case of any questions.

3.2.5. Calculation of player days

A total of 8 teams were studied during the tournament, and the daily squad sizes varied between 28-36 players per team. As a result of some teams starting and finishing at slightly different dates due to success in the tournament (either being knocked out prior to or in the quarter-final, semi-final or final) and different dates of the first games, the total tournament days for each team were therefore variable. The team physician reported the daily squad size each day. Squad sizes tended to also be reduced during the times of international travel. Therefore, the total player days for each team were calculated as follows: *total team tournament days x daily squad size (for each day)*. The total player days were 22676 for all the teams (5 South African teams=14291, 3 New Zealand teams=8385).

3.2.6. Calculation of the incidence of illness

Illness incidence data was calculated as number of illnesses per 1000 player days. Data were calculated as incidence of all illnesses, and illnesses in different systems (respiratory system and gastro-intestinal system) and for common specific diagnoses. Time-loss illnesses were also

reported and both new and repeat illnesses were included in the incidence reports. *Repeat illnesses* were defined as 'any illness in the same player with the same final diagnostic code that was recorded within 7 days'. A time-loss illness was defined as 'an illness resulting in one or more lost training or match days'.

3.2.7. Determination of risk factors associated with illness

During the tournament, 141 players developed any illness. The number of players who never developed any illness (no illness group – Control), players who developed any illness (Any illness group) and players who developed illness in the respiratory system (Respiratory illness group) or the digestive system (Digestive illness group) in each team, is depicted in Table 3.2.

Table 3.2. The number of players (and % players) in the no illness (control), any illness, respiratory illness, and digestive system illness groups. The number of players in each group by team is also included.

Groups	All players (n=239) (% of players)	Team number							
		1	2	3	4	5	6	7	8
No illness control group	98 (41.0)	8	17	15	12	2	14	7	23
Any illness group	141 (59.0)	20	11	19	23	12	25	24	7
Respiratory illness group	80 (33.5)	7	11	10	7	6	18	18	3
Digestive system illness group	60 (25.1)	10	1	11	13	5	11	5	4

The risk factors for developing 1) any illness, 2) a respiratory illness and 3) a digestive system illness were studied. The following potential risk factors were studied: the training history in the 15 weeks as well as the 2 weeks prior to the commencement of the tournament [this was divided into the volume of training (days/week and hours/week) as well as the type of training, rugby specific training, strength training, endurance and flexibility)]; medication use (asthma medication or anti-inflammatories), supplement use (any supplement, anti-oxidant, multi-vitamin, immune booster); lifestyle factors (smoking and alcohol use per week); a family history of asthma or allergies; the players immunization history (H1N1, varicella, hepatitis A and B, measles, meningitis, tetanus, yellow fever); the player medical history of asthma, allergies (any allergy, hay fever, sinusitis, allergic asthma) or a recent flu-like illness or close contact with someone with flu-like illness 1 week and 6 weeks before the tournament.

3.2.8. Statistical analysis of data

All data from the medical questionnaire were entered into an Excel spread sheet (Microsoft 2010) and then analysed using the SAS Enterprise Guide (V6.1) statistical program. Factors associated with all illness, respiratory illness and gastrointestinal illness were first determined using a uni-variate analysis. A multiple regression analysis was then performed to identify independent risk factors associated with all illness, respiratory illness and gastrointestinal illness. The statistical significance level for selection was 5%, unless specified otherwise.

3.3. Results

Factors associated with the development of any illness, respiratory illness and digestive illness in rugby players were first identified in a uni-variate analysis.

3.3.1. Factors associated with any illness (Uni-variate analysis)

There was no difference in the average age, height, weight or BMI of the players with any illness and those in the control group.

3.3.1.1. Training factors

The training history (days per week, hours per week), and type of training in the 2-week period prior to, and the 15-week period prior to the commencement of the tournament in the rugby players with no illness (control group) and players with any illness is depicted in Table 3.1. In addition, the % players who trained more than 4 days per week, and more than 10 hours per week in the 2 weeks before the tournament in the two groups is also shown in Table 3.3

Table 3.3. A training history (% players) in the last 15 weeks and the last 2 weeks according to days and hours per week, and type of training (rugby, strength, endurance and flexibility)

		Control group (n=98)	Any illness group (n=141)	P value
Training (last 15 weeks)	Days per week (mean (SD))	4.8 (0.7)	4.8 (1.1)	0.692
	Hours per week (mean (SD))	15.6 (6.2)	16.4 (6.9)	0.378
	Type (rugby) (% players)	34.2 (17.7)	31.3 (15.7)	0.720
	Type (strength) (% players)	31.9 (13.8)	34.4 (14.5)	0.976
	Type (endurance) (% players)	25.7 (11.0)	29.3 (14.2)	0.285
	Type (flexibility) (% players)	10.5 (7.0)	9.5 (5.6)	0.330
Training (last 2 weeks)	Days per week (mean (SD))	4.2 (0.8)	4.7 (1.0)	0.038 *
	Hours per week (mean (SD))	11.2 (5.2)	14.3 (6.7)	0.012 *
	Type (rugby) (% players)	52.4 (18.6)	49.2 (14.9)	0.863
	Type (strength) (% players)	24.7 (9.3)	27.8 (10.0)	0.177
	Type (endurance) (% players)	13.9 (7.7)	16.5 (9.4)	0.477
	Type (flexibility) (% players)	11.0 (7.6)	10.7 (6.0)	0.924
	Training > 4 days per week (% players)	29.6	50.0	0.201
	Training > 10 hours (% players)	34.7	60.2	0.011 *

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the two groups with regard to volume of training (days/week and hours/week), and type of training (rugby training, strength, endurance and flexibility in the 15 weeks prior to the tournament). There was also no significant difference between the two groups with regard to type of training (rugby training, strength, endurance and flexibility in the 2 weeks prior to the tournament). However, in the 2-week period prior to the tournament, players in the any illness group trained significantly more days per week [any illness group = 4.7 (1.0); control group 4.2 (0.8); $p = 0.038$] and more hours per week [any illness group = 14.3 (6.7); control group = 11.2 (5.2); $p = 0.012$] than players in the control group. Finally, a significantly greater % of players in the any illness group trained more than 10 hours per week in the 2 weeks prior to the tournament compared with the players in the control group (any illness group = 60.2%; control group = 34.7%; $p = 0.011$).

3.3.1.2. Medication use, supplements use and lifestyle factors

The use of medication, supplement usage, and lifestyle habits in the control group and the any illness group is shown in Table 3.4

Table 3.4. History of medication use (% players), supplement use (% players) and lifestyle habits (% players ever smoking, and weekly alcohol intake) in rugby players with no illness (control group) and players with any illness

		Control group (n=98)	Any Illness group (n=141)	P value
Medication use	Current asthma medication (% players)	2.0	3.6	0.785
	Current anti-inflammatories (% players)	1.0	7.8	0.059#
Supplement use	Any supplement use (% players)	85.7	85.1	0.452
	Anti-oxidant use (% players)	27.6	14.9	0.108
	Multivitamins use (% players)	51.0	44.0	0.375
	Immune boosters use (% players)	21.4	12.8	0.372
Lifestyle habits	Smoke (ever) (% players)	11.5	6.5	0.264
	Alcohol use per week (Beer) [mean (SD)]	3.1 (2.9)	3.1 (2.9)	0.759
	Alcohol per week (Wine) [mean (SD)]	0.8 (1.4)	0.6 (1.2)	0.652
	Alcohol per week (Spirits) [mean (SD)]	1.1 (2.4)	1.8 (3.8)	0.106

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the groups for medication use, supplement use, and lifestyle habits. However, there was a trend for greater % players in the any illness group to use anti-inflammatory medication compared with the control group (any illness group = 7.8%; control group = 1.0%; $p = 0.059$). However, it should be noted that only 5% of all the players used anti-inflammatory medication.

3.3.1.3. Family history of asthma and allergies

A positive family history of asthma and allergies of players in the control group and those players in the any illness group is shown in Table 3.5.

Table 3.5. Family history of asthma or allergies (% players) in rugby players with no illness (control group) and players with any illness

		Control group (n=98)	Any Illness group (n=141)	P value
Family history (% players)	Asthma	22.5	17.1	0.094 #
	Allergies	14.6	13.0	0.442

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the groups for a family history of asthma or allergies. However, there was a trend for greater % players in the control group to have a positive family history of asthma compared with the players in the any illness group (control group = 22.5%; any illness group = 17.1%; $p = 0.094$).

3.3.1.4. Immunization history

The history of immunizations (% players) in the two groups is depicted in Table 3.6.

Table 3.6. History of immunizations (% players) in rugby players with no illness (control group) and players with any illness

Immunizations (% players)	Control group (n=98)	Any Illness group (n=141)	P value
H1N1	26.9	32.8	0.744
Varicella	47.8	25.8	0.026 *
Hepatitis A	37.5	46.2	0.587
Hepatitis B	38.2	50.0	0.491
Measles	78.1	76.1	0.651
Meningitis	41.4	23.9	0.089 #
Tetanus	80.7	85.8	0.594
Yellow fever	7.0	7.0	0.645

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

A significantly smaller % players in the any illness group reported immunization against varicella (control group = 47.8%; any illness group = 25.8%; $p = 0.026$). There was no significant difference in the two groups for other immunizations, apart from a trend that that a smaller % players in the any illness group reported immunization against meningitis compared with the control group (control group = 41.4%; any illness group = 23.9%; $p = 0.089$).

3.3.1.5. Medical history of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness

The medical history of asthma, allergies or a recent flu-like illness or contact with flu-like illness (1 week and 6 weeks before the tournament) in the two groups is depicted in Table 3.7.

Table 3.7. History of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness (% players) in rugby players with no illness (control group) and players with any illness

		Control group (n=98)	Any Illness group (n=141)	P value
Current asthma (%)		5.2	7.2	0.821
Allergy history (%)	Allergy	21.9	24.6	0.810
	Hay fever	14.3	11.4	0.227
	Sinusitis	5.1	7.8	0.466
	Allergic asthma	5.1	2.1	0.101
Recent flu-like symptoms (%)	Last 1 week	10.3	8.6	0.439
	Last 6 weeks	11.2	14.3	0.829
Close contact with flu-like illness (%)	Last 1 week	17.0	9.4	0.049 *
	Last 6 weeks	28.4	22.9	0.127

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the two groups in the % players reporting current asthma, a history of allergies, flu-like symptoms in the period before the tournament, or close contact with flu-like illness in the 6 weeks before the tournament. However, a significantly larger % players in the control group reported close contact with flu-like illness in the week before the tournament, compared with players in the any illness group (control = 17.0%; any illness group = 9.4%; $p = 0.049$).

3.3.2. Factors associated with respiratory illness (Uni-variate analysis)

There was no difference in the average age, height, weight or BMI of the players with any illness and those in the control group.

3.3.2.1. Training factors

The training history (days per week, hours per week) and type of training in the 2-week period, and the 15-week period, prior to the commencement of the tournament in the rugby players with no illness (control group) and players with respiratory illness is depicted in Table 3.8. In addition, the % players who trained more than 4 days per week, and more than 10 hours per week in the 2 weeks before the tournament in the two groups is also shown in Table 3.8.

Table 3.8. A training history (% players) in the last 15 weeks and the last 2 weeks according to days and hours per week, and type of training (rugby, strength, endurance and flexibility)

		Control group (n=98)	Respiratory illness group (n=80)	P value
Training (last 15 weeks)	Days per week (mean (SD))	4.8 (0.7)	5.0 (1.2)	0.748
	Hours per week (mean (SD))	15.6 (6.2)	15.7 (6.7)	0,885
	Type (rugby) (% players)	34.2 (17.7)	31.8 (16.1)	0,941
	Type (strength) (% players)	31.9 (13.8)	34.8 (15.9)	0,828
	Type (endurance) (% players)	25.7 (11.0)	30.5 (14.1)	0,084#
	Type (flexibility) (% players)	10.5 (7.0)	10.2 (6.3)	0,545
Training (last 2 weeks)	Days per week (mean (SD))	4.2 (0.8)	4.7 (1.1)	0.025*
	Hours per week (mean (SD))	11.2 (5.2)	13.1 (6.6)	0.137
	Type (rugby) (% players)	52.4 (18.6)	52.9 (15.1)	0,508
	Type (strength) (% players)	24.7 (9.3)	27.5 (12.1)	0,295
	Type (endurance) (% players)	13.9 (7.7)	14.9 (8.3)	0,977
	Type (flexibility)(% players)	11.0 (7.6)	10.5 (5.7)	0,856
	Training > 4 days per week (% players)	29.6	49.2	0.097#
	Training > 10 hours (% players)	34.7	43.1	0.458

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the two groups with regard to volume of training (days/week and hours/week), and type of training (rugby training, strength, endurance and flexibility) in the 15 weeks prior to the tournament. There was a tendency that a greater % of players who took part in endurance type training in the 15 weeks prior to the tournament reported respiratory illness [respiratory illness group = 30.5 (14.1); control group = 25.7 (11.0); $p = 0.084$]. There was no significant difference between the two groups with regard to type of training (rugby training, strength, endurance and flexibility) in the 2 weeks prior to the tournament. However, in the 2-week period prior to the tournament, players in the respiratory illness group trained significantly more days per week [respiratory illness group = 4.7 (1.1); control group = 4.2 (0.8); $p = 0.025$] than players in the control group.

3.3.2.2. Medication use, supplements use and lifestyle factors

The use of medication, supplement usage and lifestyle habits in the control group and the respiratory illness group are shown in Table 3.9.

Table 3.9. History of medication use (% players), supplement use (% players) and lifestyle habits (% players ever smoking, and weekly alcohol intake) in rugby players with no illness (control group) and players with respiratory illness

		Control group (n=98)	Respiratory Illness group (n=80)	P value
Medication use	Current asthma medication (% players)	2.0	3.8	0.815
	Current anti-inflammatories (% players)	1.0	8.8	0.054#
Supplements use	Any supplement use (% players)	85.7	85.0	0.368
	Anti-oxidants (% players)	27.6	20.0	0.169
	Multivitamins (% players)	51.0	53.8	0.485
	Immune boosters (% players)	21.4	17.5	0.408
Lifestyle habits	Smoke (ever) (% players)	11.5	6.3	0.408
	Alcohol use per week (Beer)	3.1	3.1	0.820
	Alcohol per week (Wine)	0.8	0.6	0.813
	Alcohol per week (Spirits)	1.1	1.9	0.107

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the groups for medication use, supplement use, and lifestyle habits. There was a trend that a greater % of players reported using anti-inflammatory medication developed a respiratory illness [respiratory illness group = 8.8; control group = 1.0; $p = 0.054$] as compared to the control group. Only 4.5% of the players used anti-inflammatory medication.

3.3.2.3. Family history of asthma and allergies

A positive family history of asthma and allergies of players in the control group and those players in the respiratory illness group are shown in Table 3.10.

Table 3.10. Family history of asthma or allergies (% players) in rugby players with no illness (control group) and players with respiratory illness

		Control group (n=98)	Respiratory Illness group (n=80)	P value
Family history (% players)	Asthma	22.5	17.5	0.249
	Allergies	14.6	13.8	0.889

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the groups for a family history of asthma or allergies.

3.3.2.4. Immunization history

The history of immunizations (% players) in the two groups is depicted in Table 3.11.

Table 3.11. History of immunizations (% players) in rugby players with no illness (control group) and players with respiratory illness

	Control group (n=98)	Respiratory illness group (n=80)	P value
H1N1	26.9	27.6	0.761
Varicella	47.8	32.4	0.148
Hepatitis A	37.5	45.5	0.255
Hepatitis B	38.2	46.2	0.272
Measles	78.1	80.8	0.716
Meningitis	41.4	28.0	0.307
Tetanus	80.7	87.3	0.206
Yellow Fever	7.0	8.1	0.339

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference in the two groups for other immunizations.

3.3.2.5. Medical history of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness

The medical history of asthma, allergies or a recent flu-like illness or contact with flu-like illness (1 week and 6 weeks before the tournament) in the two groups is shown in Table 3.12.

Table 3.12. History of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness (% players) in rugby players with no illness (control group) and players with respiratory illness

		Control group (n=98)	Respiratory Illness group (n=80)	P value
Current asthma (%)		5.2	7.5	0.845
Allergy history (%)	Allergy	21.9	27.5	0.661
	Hay fever	14.3	13.8	0.432
	Sinusitis	5.1	10.0	0.422
	Allergic asthma	5.1	3.8	0.270
Recent flu-like symptoms (%)	Last 1 week	10.3	13.8	0.858
	Last 6 weeks	11.2	17.5	0.331
Close contact with Flu-like illness (%)	Last 1 week	17.0	7.7	0.038 *
	Last 6 weeks	28.4	22.5	0.231

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the two groups in the % players reporting current asthma, a history of allergies, flu-like symptoms in the period before the tournament, or close contact with flu-like illness in the 6 weeks before the tournament. However, there was a significantly larger % players in the control group reporting close contact with individuals suffering from flu-like illness in the week before the tournament, compared with players in the respiratory illness group (control = 17.0%; respiratory illness group = 7.7%; $p = 0.038$).

3.3.3. Factors associated with digestive illness (Uni-variate analysis)

On average, the players with digestive illness were 1 year older and also 5 kg heavier than the players without a digestive illness.

3.3.3.1. Training factors

The training history (days per week, hours per week) and type of training in the 2-week period prior to, and the 15 weeks prior to the commencement of the tournament in the rugby players with no illness (control group) and players with digestive system illness is depicted in Table 3.13. In addition, the % players who trained more than 4 days per week, and more than 10 hours per week in the 2 weeks before the tournament in the two groups is also shown in Table 3.13.

Table 3.13. A training history (% players) in the last 15 weeks and the last 2 weeks according to days and hours per week, and type of training (rugby, strength, endurance and flexibility)

		Control group (n=98)	Digestive System Illness (n=60)	P value
Training (last 15 weeks)	Days per week (mean (SD))	4.8 (0.7)	4.7 (1.2)	0.309
	Hours per week (mean (SD))	15.6 (6.2)	14.7 (6.4)	0.727
	Type (rugby) (% players)	34.2 (17.7)	30.1 (15.0)	0.993
	Type (strength) (% players)	31.9 (13.8)	31.6 (12.9)	0.621
	Type (endurance) (% players)	25.7 (11.0)	29.9 (12.8)	0.566
	Type (flexibility) (% players)	10.5 (7.0)	10.0 (6.2)	0.702
Training (last 2 weeks)	Days per week (mean (SD))	4.2 (0.8)	4.8 (1.3)	0.041 *
	Hours per week (mean (SD))	11.2 (5.2)	14.4 (6.0)	0.025 *
	Type (rugby) (% players)	52.4 (18.6)	44.9 (14.2)	0.238
	Type (strength) (% players)	24.7 (9.3)	27.6 (8.9)	0.213
	Type (endurance) (% players)	13.9 (7.7)	17.1 (9.3)	0.446
	Type (flexibility) (% players)	11.0 (7.6)	11.7 (6.4)	0.670
	Training > 4 days per week (% players)	29.6	54.4	0.083 #
Training > 10 hours in 2 weeks (% players)	34.7	68.9	0.004 *	

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the two groups with regard to volume of training (days/week and hours/week), and type of training (rugby training, strength, endurance and flexibility) in the 15 weeks prior to the tournament. There was also no significant difference between the two groups with regard to type of training (rugby training, strength, endurance and flexibility) in the 2 weeks prior to the tournament. However, in the 2-week period prior to the tournament, players in the digestive system illness group trained significantly more days per week [digestive system illness group = 4.8 (3.1); control group 4.2 (0.8); $p = 0.041$] and more hours per week [digestive system illness group = 14.4 (6.0); control group = 11.2 (5.2); $p = 0.025$] than players in the control group. In addition, a significantly greater % of players in the digestive system illness group trained more than 10 hours per week in the 2 weeks prior to the tournament compared with the players in the control group (digestive system illness group = 68.9%; control group = 34.7%; $p = 0.004$). There was also a trend towards a greater % of players in the digestive

system illness group who reported training more than 4 days per week in the 2 weeks before the tournament (digestive system illness group = 54.4%; control group = 29.6%; $p = 0.083$).

3.3.3.2. Medication use, supplements use and lifestyle factors

The use of medication, supplement usage and lifestyle habits in the control group and the digestive system illness group are shown in Table 3.14.

Table 3.14. History of medication use (% players), supplement use (% players) and lifestyle habits (% players ever smoking, and weekly alcohol intake) in rugby players with no illness (control group) and players with digestive system illness

		Control group (n=98)	Digestive system illness (n=60)	P value
Medication use	Current asthma medication (% players)	2.0	3.3	0.830
	Current anti-inflammatories (% players)	1.0	8.3	0.028 *
Supplements use	Any supplement use (% players)	85.7	76.7	0.096 #
	Anti-oxidants (% players)	27.6	10.0	0.114
	Multivitamins (% players)	51.0	33.3	0.189
	Immune boosters (% players)	21.4	5.0	0.065 #
Lifestyle habits	Smoke (ever) (% players)	11.5	3.5	0.125
	Alcohol use per week (Beer)	3.1	2.9	0.784
	Alcohol per week (Wine)	0.8	0.6	0.720
	Alcohol per week (Spirits)	1.1	1.4	0.524

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the groups for supplement use, and lifestyle habits. There was a significantly greater % of players in the digestive system illness group who reported use of anti-inflammatory medication (digestive system illness group = 8.3%; control = 1.0%; $p = 0.028$) compared with players in the control group. In addition, there was a trend that a smaller % players in the digestive system illness group reported using any supplement (digestive system illness group = 76.7%; control = 85.7%; $p = 0.096$). There was also a trend that a smaller % of players in the digestive system illness group reported using immune boosters (digestive system illness group = 5%; control = 21.4%; $p = 0.065$) compared to the control group.

3.3.3.3. Family history of asthma and allergies

A positive family history of asthma and allergies of players in the control group and those players in the digestive system illness group are shown in Table 3.15.

Table 3.15. Family history of asthma or allergies (% players) in rugby players with no illness (control group) and players with digestive system illness

	Control group (n=98)	Digestive system illness (n=60)	P value
Asthma	22.5	17.0	0.225
Allergies	14.6	5.2	0.039 *

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the groups for a family history of asthma. However there was a significantly smaller % of players in the digestive system illness group that reported a positive family history of allergies (digestive system illness group = 5.2%; control = 14.6%; $p = 0.039$) compared to the control group.

3.3.3.4. Immunization history

The history of immunizations (% players) in the two groups is depicted in Table 3.16.

Table 3.16. History of immunizations (% players) in rugby players with no illness (control group) and players with digestive system illness

	Control group (n=98)	Digestive system illness (n=60)	P value
H1N1	26.9	29.8	0.421
Varicella	47.8	11.3	0.001 *
Hepatitis A	37.5	42.6	0.341
Hepatitis B	38.2	49.1	0.517
Measles	78.1	77.2	0.703
Meningitis	41.4	16.7	0.020*
Tetanus	80.7	82.1	0.371
Yellow Fever	7.0	0.0	NA

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

NA: Not analyzed (too small sample size)

A significantly smaller % of players in the digestive system illness group reported immunization against varicella compared to the control group (control group = 47.8%; digestive system illness

group = 11.3%; p = 0.001). There was also a significantly smaller % of players in the digestive system illness group who reported immunization against meningitis (control group = 41.4%; digestive system illness group = 16.7%; p = 0.020).

3.3.3.5. Medical history of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness

The medical history of asthma, allergies or a recent flu-like illness or contact with flu-like illness (1 week and 6 weeks before the tournament) in the two groups is shown in Table 3.17.

Table 3.17. History of current asthma, allergies, recent flu-like illness and close contact with individuals with flu-like illness (% players) in rugby players with no illness (control group) and players with digestive system illness

		Control group (n=98)	Digestive system illness (n=60)	P value
Current asthma (%)		5.2	10.2	0.282
Allergy history (%)	Allergy	21.9	19.0	0.653
	Hay fever	14.3	13.3	0.634
	Sinusitis	5.1	8.3	0.448
	Allergic asthma	5.1	0.0	
Recent flu-like symptoms (%)	Last 1 week	10.3	3.4	0.116
	Last 6 weeks	11.2	10.2	0.767
Close contact with Flu-like illness (%)	Last 1 week	17.0	5.2	0.063 #
	Last 6 weeks	28.4	20.3	0.149

#: Indicates trend towards a significant difference between groups: $0.05 < p < 0.1$

*: Indicates significant differences between groups: $p < 0.05$

There was no significant difference between the two groups in the % players reporting current asthma, a history of allergies, flu-like symptoms in the period before the tournament, or close contact with flu-like illness in the 6 weeks before the tournament. However, there was a trend towards a smaller % of players in the digestive system illness group who reported a close contact with a flu-like illness in the week before the tournament (control group = 17.0%; digestive system illness group = 5.2%; p = 0.063).

3.3.4. Independent risk factors associated with any illness, respiratory illness and digestive illness (Multiple regression analysis)

Independent risk factors associated with any illness, respiratory system illness and digestive system illness in rugby players are depicted in Table 3.18.

Table 3.18. Independent risk factors associated with any illness, respiratory system illness and digestive system illness in rugby players (multiple regression analysis)

Group	Risk factor	Estimate	SE	F	p value	OR	95% CI
Any illness	Training days in the 2 weeks before the tournament	0.543	0.26	4.36	0.038	1.72	1.03 – 2.88
Respiratory system illness	Training days in the 2 weeks before the tournament	0.593	0.25	5.5	0.021	1.81	1.10 – 2.98
	% endurance training time in the 15 weeks before the tournament	0.04	0.02	5.57	0.02	1.04	1.01 – 1.08
	Use of anti-inflammatory drugs	2.47	1.14	4.59	0.034	11.7	1.2 - 114
Digestive system illness	Training days in the 2 weeks before the tournament	0.8	0.32	6.35	0.013	2.2	1.2 – 4.2
	Varicella vaccination	2.11	0.59	12.86	0.0005	8.3	2.6 – 26.7

An increased number of training days in the 2 weeks before the tournament was an independent risk factor for any illness (OR = 1.72; 95% CI, 1.03 to 2.88; p=0.038), respiratory system illness (OR = 1.81; 95% CI, 1.10 to 2.98; p = 0.021), and digestive system illness (OR = 2.2; 95% CI, 1.2 to 4.2; p = 0.013). In all 3 cases the odds of illness increase with about 2 points for every 1 additional day of training.

The % time spent on endurance training in the 15 weeks before the tournament (OR = 1.04; 95% CI, 1.01 to 1.08; p = 0.02), and the use of anti-inflammatory drugs (OR = 11.7; 95% CI, 1.2 to 114; p = 0.034) were additional independent risk factors associated with respiratory system illness. The odds for developing a respiratory illness was 11 times higher for players taking anti-inflammatory medications compared to those who did not.

No vaccination against varicella was an additional independent risk factor associated with digestive system illness (OR = 8.3; 95% CI, 2.6 to 26.7; p = 0.0005). The odds for a digestive

illness were 8 times higher for players without varicella vaccination compared to those with varicella vaccination.

3.4. Discussion

In this prospective cohort study, intrinsic risk factors for the development of illness (any illness, respiratory system illness, and digestive system illness) in elite rugby players participating in a 16-week tournament were explored. Specifically, the following intrinsic risk factors were studied: training history prior to the commencement of the tournament, current medication and supplement use, lifestyle factors, a family history of asthma or allergies, player immunization history, player medical history of asthma and allergies, and exposure to flu-like illness or close contact with someone with flu-like illness before the tournament.

The main findings of this study are that: 1) an increased number of training days in the 2 weeks before the tournament was an independent risk factor for any illness, respiratory system illness, and digestive system illness, 2) the % time spent on endurance training in the 15 weeks before the tournament, and the use of anti-inflammatory drugs were additional independent risk factors associated with respiratory system illness, 3) no vaccination against varicella was an additional independent risk factor associated with digestive system illness, and 4) medication and supplement use, lifestyle factors, a family history of asthma or allergies, player medical history of asthma and allergies, and exposure to flu-like illness or close contact with someone with flu-like illness before the tournament were not associated with increased risk of illness.

This study is, to our knowledge, the first prospective cohort study to determine potential intrinsic risk factors for illness in rugby players during a tournament, in this particular case the 2010 Super Rugby tournament. Consequently, it is difficult to make comparisons with previous studies. It has previously been shown that there is a high incidence of illness (20.7/1000 player days) during the same tournament [7], and that the predominant illnesses were of the respiratory and digestive systems [7]. Similar patterns of illness in the different systems have also been documented in several other studies across different sporting codes, including the 2009 FIFA Confederations Cup [13], FIFA 2010 World Cup football [11], 2012 Summer Olympic Games [17], 2010 Winter Olympic Games [19] and 2009 FINA World Championships (aquatics) [14]. However, there have

been no studies examining intrinsic player factors that may be related to the incidence of illness in rugby players. To our knowledge, the only other study to date to examine risk factors for illness in other elite athletes was conducted in outdoor athletics on 1342 registered athletes during the 2012 Helsinki European Athletics Championships [83]. In this study, it was concluded that illness risk factors remain unclear.

The first main finding in our study was that an increased number of training days in the 2 weeks before the tournament was an independent risk factor for any illness, respiratory system illness, and digestive system illness. This indicates two potential factors for consideration 1) that higher training volumes in a short period (2 weeks) could place players at a higher risk of developing an illness and 2) that there is an increased incidence of illness close to the start of a competition. Our finding is consistent with observations reported in other sports.

There is some evidence in studies, to suggest that there is a relationship between increased training volumes (hours/day or days/week) and increased risk of illness in elite athletes. In a study conducted at the Australian Institute of Sport, 32 elite male and female triathletes and cyclists, 31 male and female recreationally competitive triathletes and cyclists, and 20 male and female untrained sedentary controls were recruited for a 5-month prospective surveillance study. The results showed that the highest cluster of illness episodes occurred during the highest training periods of December and January. It also reported that elite athletes accounted for 57% of all cases [30]. In a study investigating the incidence of URTI during the Two Oceans Ultra-Marathon (56km) in South Africa, it was documented that runners who completed the highest training weekly distance (kilometers/week) in preparation for the race experienced the highest incidence of symptoms of URT symptoms [84]. In a prospective cohort study of 35 elite yachtsmen during the 2003 America's Cup race, periods of high training volume were a major risk factor for the development of illness [27]. However, in this study no further information was given regarding the exact volumes of training studied.

Upper respiratory tract infections (URTI) are commonly experienced by elite endurance athletes, particularly around the time of competition [30]. There is evidence that illnesses cluster around the time of competition possibly as a consequence of training-induced immunosuppression, increased anxiety and psychosocial stress, and increased exposure to pathogens [57] [65]. In a review of studies of immunity in elite athletes and associations with intensity, volume and

duration of exercise, it was concluded that following relatively short periods (1–3 weeks) of intensified training (longer duration and higher volume), marked reductions in neutrophil function, lymphocyte proliferation, sIgA, and the circulating number of T cells producing IFN- γ (interferon gamma) were observed [85]. It was suggested that these immune changes are associated with an increased risk of respiratory illness in the athletes.

Similarly, Nieman proposed a J-shaped Model which shows the relationship between exercise workload and URTI risk [86]. This model suggests that the risk of URTI symptoms may decrease below that of a sedentary individual when one engages in moderate exercise training. But the risk of URTI symptoms may rise above average during periods of excessive amounts of high-intensity exercise.

Again, in our study we found that an increased volume of training (days/week) in the period 2 weeks before the 2010 Super 14 Rugby tournament was associated with a significantly higher risk of illness. This is consistent with the aforementioned studies, which show that increased training volumes and intensities result in a suppression of the immune system that places athletes at a higher risk of illness.

Apart from increased days of training, we also found that the % time spent on endurance training in the 15 weeks before the tournament (OR = 1.04; 95% CI, 1.01 to 1.08; $p = 0.02$) was an additional independent risk factor associated with respiratory system illness. It has been documented that some endurance athletes undergoing strenuous training have an increased susceptibility to URTI as a result of exercise-induced immunosuppression [57]. Components of the immune system respond differently to the chronic stress of intense, endurance-type exercise [1]. While the adaptive immune system remains largely unchanged, the innate immune system undergoes changes with an enhancement of natural killer cell activity and a suppression of neutrophil function. In the literature this period of an altered immune state is referred to as the ‘open window’. During this ‘open window’, which may last between 3 and 72 hours, viruses and bacteria may proliferate increasing the risk of subclinical and clinical infection [1].

It has been suggested by investigators that athletes showing the most extreme post-exercise immunosuppression are also those athletes that contract an infection during the ensuing 1 to 2 weeks [1]. This was studied in a group of 150 randomly selected Ultra-Marathon runners in the Two Oceans marathon in Cape Town where symptoms of URTI occurred in 33.3% of runners during the 2 week period following the race [84].

Several studies have demonstrated that the concentration and flow rate of secretory immunoglobulin A (sIgA), the major effector of host resistance to URTI, decreases after intense endurance exercise [85] [57]. It has been documented that there is a correlation between a decrease in SIgA (particularly salivary IgA1) during training [56], and an increase in the number of respiratory infections in elite athletes. Future studies may begin to focus on other factors, including genetic factors, which may predispose athletes to illness. Cox et al have already examined cytokine gene polymorphisms and have found a possible link with upper respiratory symptoms (URS) in highly trained athletes [87].

In our study, the use of anti-inflammatory drugs was an independent risk factor associated with respiratory system illness (OR = 11.7; 95% CI, 1.2 to 114; $p = 0.034$). From our data, it is not clear what the relationship between the use of anti-inflammatory drugs and respiratory illness is. Furthermore, the data also needs to be interpreted with caution because overall only very few players reported use of anti-inflammatory medication (<5%). The reasons why players made use of anti-inflammatory medication were also not studied. One possible explanation is that players who have a propensity towards respiratory system illness took anti-inflammatory medication as a precaution or preventative measure, and this has been previously reported as a measure to reduce the effect of ongoing airway inflammation [88]. In future studies, the relationship between anti-inflammatory medication use and risk of respiratory illness needs to be explored.

In our study we showed that there was a relationship between no reported vaccination against varicella, and increased risk factor of digestive system illness (OR = 8.3; 95% CI, 2.6 to 26.7; $p = 0.0005$). However, we also noted a large variation in reported varicella immunizations among players and not all players completed this question. Hence, this finding needs to be interpreted with caution. There are no known data that link the administration of the varicella vaccine to the development of digestive system illness, and this could possibly be explored further in future studies.

In our study we also report several factors that were not associated with an increased risk of illness. The use of asthma medication was not found to be an independent risk factor. Similarly, player medical history of asthma or allergies, as well as a family history of asthma or allergies, was also not found to be a risk factor for the development of illness. Players that made use of

supplements, anti-oxidants, multivitamins or immune boosters were not at a significantly reduced risk for illness than those who never used them. Interestingly, players who smoked or consumed alcohol were not at any significant risk of illness compared to those who never smoked or use alcohol. Lastly, we found that players who had had close contact with someone who was suffering from a flu-like illness did not significantly affect the player's risk of developing an illness. Future studies could record close contact with someone with gastroenteritis and the associated risk of developing digestive system illness.

Given all these observations, there is substantial clinical interest in understanding the relationships between exercise, training, immune function and the practical intervention strategies to maintain immuno-competence in athletes undertaking intensive training programs [89] prior to and especially during competition time. Sports performance may be reduced during times of illness and this remains a concern for coaches, athletes and medical staff alike [90]. For example, during the Winter Olympic Games 2010 [19], it was reported that a reduced illness rate in the Norwegian team was associated with a higher team performance.

The identification of risk factors for illness will allow medical staff to develop and implement preventative measures for illness, specifically respiratory and digestive system illness. An example of the practical implementation of preventative measures to improve performance was reported in the Norwegian Winter Olympics team [41]. In this study, it was concluded that athletes with a heavy competition load and resultant increased susceptibility to respiratory tract infections and airway problems were accommodated for the most part in single rooms. Various other strategies were also strongly advised, and included the use of disinfectant hand gels, minimizing of hand-shaking, and the use of special indoor air cleaning systems [41].

Another study suggested the monitoring of mucosal immune parameters (such as salivary IgM and IgA) during critical training periods and establishing personal profiles for individual athletes which may provide an assessment of the risk status of an athlete for URTI [85]. Prophylactic antibiotics (ciprofloxacin) were used by the medical team to lower the incidence of Travellers' Diarrhoea (TD) in Team England athletes to the Youth Commonwealth Games in India in 2008 [34]. Another study suggested the monitoring of mucosal immune parameters (such as salivary IgM and IgA) during critical training periods and establishing personal profiles for individual athletes which may provide an assessment of the risk status of an athlete for URTI [85].

The practical clinical application from our study findings is a recommendation to include the tapering of training loads in the 2 weeks before the commencement of the tournament as well as to consider reductions in the endurance-training element in the pre-season period (approximately 15 weeks before the tournament). It has also previously been suggested that following illness, a hierarchical return to full training be implemented, where the frequency of sessions is increased first, followed by a systematic increase in training volume or duration, and finishing with increases in intensity of training [91]. We also noted the possible relationship between illness and anti-inflammatory medication and therefore team physicians should discourage the excessive use of anti-inflammatories.

3.5. Strengths and limitations of the study

The strengths of the present study are that it is, to our knowledge, the first prospective cohort study to determine intrinsic player factors associated with illness in elite rugby players. This study represents a large prospective cohort study in rugby union, and was conducted in a tournament of a long duration played at a very high level. Furthermore, team physicians recorded daily illness data with a very high compliance rate, and the incidence rate of illness was accurately documented.

However, the team physician used clinical criteria in concluding their diagnosis as laboratory studies or other special investigations were not consistently available. There was also a reliance on players to accurately recall and enter their medical history, including immunizations and family history of asthma and allergies. In addition, training loads were not documented during the tournament - only before the tournament. Finally, these data may not be generalizable to other sporting codes as the study was conducted in Rugby Union players during a tournament.

3.6. Summary and clinical implications

In summary, the main findings and clinical implications of the data presented in this study are:

- An increased number of training days in the 2 weeks before the tournament was an independent risk factor for any illness, respiratory system illness, and digestive system illness.

- Higher training volumes in a short period (2 weeks) could place players at a higher risk of developing an illness.
- There is an increased incidence of illness close to the start of a competition.
- The % time spent on endurance training in the 15 weeks before the tournament was an additional independent risk factor associated with respiratory system illness.
- A recommendation to include the tapering of training loads in the 2 weeks before the commencement of the tournament as well as to consider reductions in the endurance-training element in the pre-season period (approximately 15 weeks before the tournament).
- The use of anti-inflammatory medication was an independent risk factor associated with respiratory system illness.
- Team physicians should discourage the excessive use of anti-inflammatories.
- The use of asthma medication was not found to be an independent risk factor.
- Player medical history of asthma or allergies, as well as a family history of asthma or allergies, was also not found to be a risk factor for the development of illness.
- Players that made use of supplements, anti-oxidants, multivitamins or immune boosters were not at a significantly reduced risk for illness than those who never used them.
- Players who smoked or consumed alcohol were not at any significant risk of illness compared to those who never.
- Players who had had close contact with someone who was suffering from a flu-like illness did not significantly affect the player's risk of developing an illness.
- The identification of risk factors for illness will allow medical staff to develop and implement preventative measures for illness, specifically respiratory and digestive system illness

Chapter 4

Summary and conclusion

In a number of epidemiological studies in athletes during times of training, competition or tournaments, data show that illness is an important component of athlete health and performance. Data show that illness significantly contributes to the health care of the athlete during tournaments, and that the highest incidence of illness is recorded in the respiratory system followed by the digestive system. However, to date, there are very few studies that have determined independent risk factors for illness in athletes in the tournament setting. These data are essential to plan prevention strategies to protect the health of the athlete.

The focus of this dissertation was to investigate risk factors for illness in athletes, with specific reference to the sport of Rugby Union during a 16-week international tournament. In Chapter 2, a comprehensive review, using evidence-based criteria, was undertaken to determine risk factors for illness in athletes in general, and specifically in rugby players. The main findings of this review were as follows:

- Respiratory system and digestive system illness consistently rank as the most common systems affected
- Extrinsic risk factors associated with an increased risk of illness were: international travel, close quarter living, increased competition/tournament duration, environmental factors (heat, humidity, pollution) and nutritional factors
- Intrinsic risk factors were: female sex, older age group and training associated factors
- There was little or no evidence to suggest an association with BMI, recent close contact with someone suffering from flu, history of allergy or asthma and medication use

An original research study was therefore undertaken to determine the independent intrinsic risk factors for illness in rugby players during a prolonged 16-week tournament, and this was presented in Chapter 3.

The strengths of this study are that it is, to our knowledge, the first prospective cohort study to determine intrinsic player factors associated with illness in elite rugby players. This study

represents a large prospective cohort study in Rugby Union, and was conducted in a tournament of a long duration played at a very high level.

The results of this study contributed to the body of knowledge on the risk factors for illness as follows:

- An increased number of training days in the 2 weeks before the tournament was an independent risk factor for any illness, respiratory system illness, and digestive system illness.
- The % time spent on endurance training in the 15 weeks before the tournament was an additional independent risk factor associated with respiratory system illness.
- Use of anti-inflammatory medication was an independent risk factor associated with respiratory system illness.

There is substantial clinical interest in understanding the relationships between exercise, training, immune function and the practical intervention strategies to maintain immuno-competence in athletes undertaking intensive training programs prior to and especially during competition time. The identification of risk factors for illness will assist team physicians to develop and implement preventative measures for illness, specifically respiratory and digestive system illness.

These prevention strategies can be adjusted at various points during the season to adapt to certain high risk periods. Coaches and trainers can now also anticipate how the effects of illnesses are likely to alter squad composition during and prior to the 4-month tournament and plan training sessions accordingly.

The findings from this research study therefore add to the body of knowledge on the risk factors associated with illness. The risk factors for illness presented in Chapter 2 can now be modified and summarized as follows (Table 4.1.)

Table 4.1. A summary of extrinsic and intrinsic risk factors for illness in athletes (including level of evidence for risk factors)

	Risk Factor	Study details and references	Level of Evidence (I-IV)
EXTRINSIC RISK FACTORS	International travel	Prospective cohort study [10]	I
	Athlete accommodation	Expert opinion [40]	IV
	Regular close contact with team members	Descriptive case series in Norwegian athletes [28}	III
	Increased duration of competition or tournament	Prospective cohort study [7]	I
	Environmental factors	Expert opinion [15] [14] [11] original article [45] article [35]	IV IV IV
INTRINSIC RISK FACTORS	Female sex	Prospective cohort studies [16] [17] [20] [28]	I
	Older age	Prospective cohort study [16]	I
	Body Mass Index (BMI)	No data	
	High intensity and prolonged training	Systematic reviews [62] [64] [53, 60, 61].	II
	Increased number of training days 2 weeks before tournament/competition	Prospective cohort study (dissertation)	I
	Increased endurance-type training 15 weeks before tournament or competition	Prospective cohort study (dissertation)	I
	Recent close contact with and individual suffering from an illness	Positive association: Expert opinion [42] No association: Prospective cohort study (dissertation)	IV I
	History of allergy or asthma	Positive association: Expert opinion [69] [67]	IV

		No association: Prospective cohort study (dissertation)	I
	Family history of allergy or asthma	No association: Prospective cohort study (dissertation)	I
	Medication use	Positive association: Expert opinion [16] [72]	IV
	Anti-inflammatory medication only	Prospective cohort study (dissertation)	I
	Other medication	No association: Prospective cohort study (dissertation)	I
	Nutritional factors/supplements	Positive association: Systematic review [81] [61, 80]	II
	Supplement use only	No association: Prospective cohort study (dissertation)	I
	Lifestyle factors (smoking, alcohol)	No association: Prospective cohort study (dissertation)	I

In addition, this study also highlighted the importance of recording true incidence of illness. It is therefore also suggested that the most accurate measure is illnesses per 1000 athlete days as opposed to illnesses per 1000 athletes. This will allow for more accurate comparisons to be made in illness studies in athletes across different sporting codes and durations of competition.

Practical clinical recommendations for athletes to reduce the risk of illness

Based on the review of the risk factors for elite athletes, and the findings from the original research study in this dissertation, the following practical clinical recommendations can be given to team physicians and athletes to reduce the risk of illness during training and tournaments or competition time (Table 4.2):

Table 4.2.: Practical clinical recommendations to reduce the risk of illness in athletes, based on current known and postulated risk factors for illness.

Risk factor	Practical clinical recommendation
<p>Extrinsic risk factors</p> <ul style="list-style-type: none"> • International travel • Athlete accommodation • Regular close contact with team members • Increased duration of tournament/competitions • Environmental factors <p>Intrinsic risk factors</p> <ul style="list-style-type: none"> • Female sex • Older age • BMI • High intensity training • Endurance- type/prolonged 	<ul style="list-style-type: none"> • Increased attention to enhancement of athlete immunity particularly when departing home country • Isolate ill players or players with higher susceptibility to respiratory illness from rest of team • Employ specific hygiene interventions • Increased awareness of higher incidence of illness during longer tournaments/competitions • Recommended reduction in high intensity exercise in hot, humid and air polluted conditions • Non-modifiable risk factor; increased awareness of possible higher incidence of illness • Non-modifiable risk factor; increased awareness of possible higher incidence of illness • Nil specific as yet • Limit high intensity exercise 2 weeks prior to tournament/competition; adequate recovery after high intensity exercise; • Increased risk for respiratory

<p>training</p> <ul style="list-style-type: none"> • Recent close contact with an individual suffering from an illness • History of allergy or asthma • Recent flu-like illness • Medication use • Lifestyle factors (smoking and alcohol) • Nutritional factors/supplements • Immunization history 	<p>system illness; adequate recovery post endurance exercise</p> <ul style="list-style-type: none"> • Avoidance of someone who is ill is advised • No specific increased risk of illness but beware of performance related effects • No increased risk; ensure adequate recovery before engaging in high intensity exercise • Athletes with higher susceptibility to respiratory illness to avoid excessive anti-inflammatory usage • No associated increased risk but be aware of other adverse health effects • Nutritional deficiencies associated with increased risk of illness; be aware of importance of maintaining a healthy nutritional status • No increased risk but be aware of importance of immunizations to prevent other illnesses
--	--

Recommendations for further research to reduce the risk of illness

Finally, as a result of this study, we suggest the following areas for further research.

- Continued research into the incidence of illness in elite rugby players, as this particular topic has only two research studies that we are aware of
- Further study is required to uncover the causes of unidentified but symptomatic URI in athletes
- A clear need for better understanding of the aetiology and risk factors of URTI in elite athletes
- It is suggested that future studies on the incidence of illness be reported as illnesses per 1000 athlete days in order to make comparisons with previous studies more appropriate.
- Further research into the effects of travel on the incidence of illness in athletes
- Continued studies into the relationship between allergies and illness
- Further studies into gender- and age-related higher incidences of illness
- Detecting a link between changes in nutritional status, decreases in concentration or activity of various immune system parameters, and the incidence of common illnesses such as upper respiratory tract infections requires further research to better identify this cause and effect relationship
- BMI, whether increased or decreased, and its association with illness needs to be studied further
- Considering the widespread use of medication in sports, the effects on athlete general health and risk of other illness remains an area that is not well studied in the sports medicine literature

References

1. Nieman, D. and B. Pedersen, *Exercise and Immune Function*. Sports Medicine, 1999. **27**(2): p. 73-80.
2. Steffen, K., T. Soligard, and L. Engebretsen, *The IOC's endeavour to protect the health of the athlete continues*. Br J Sports Med, 2011. **45**(7): p. 551-2.
3. Rogge, J., *An ounce of prevention?* British Journal of Sports Medicine, 2009. **43**(9): p. 627.
4. Leatherwood, W.E. and J.L. Drago, *Effect of airline travel on performance: a review of the literature*. British Journal of Sports Medicine, 2013. **47**(9): p. 561-567.
5. Rossiter, M., *ANTIBIOTIC PROPHYLAXIS OF TRAVELLERS' DIARRHOEA IN ATHLETES*. British Journal of Sports Medicine, 2014. **48**(21): p. 1581-1582.
6. Gawroński, W., J. Sobiecka, and J. Malesza, *Fit and healthy Paralympians—medical care guidelines for disabled athletes: a study of the injuries and illnesses incurred by the Polish Paralympic team in Beijing 2008 and London 2012*. British Journal of Sports Medicine, 2013. **47**(13): p. 844-849.
7. Schwellnus, M., et al., *Illness during the 2010 Super 14 Rugby Union tournament - a prospective study involving 22 676 player days*. Br J Sports Med, 2012. **46**(7): p. 499-504.
8. Williams, S., et al., *A Meta-Analysis of Injuries in Senior Men's Professional Rugby Union*. Sports Medicine, 2013. **43**(10): p. 1043-1055.
9. Cunniffe, B., et al., *Illness monitoring in team sports using a Web-based training diary*. Clin J Sport Med, 2009. **19**(6): p. 476-81.
10. Schwellnus, M.P., et al., *Elite athletes travelling to international destinations >5 time zone differences from their home country have a 2-3-fold increased risk of illness*. Br J Sports Med, 2012. **46**(11): p. 816-21.
11. Dvorak, J., et al., *Injuries and illnesses of football players during the 2010 FIFA World Cup*. Br J Sports Med, 2011. **45**(8): p. 626-30.
12. Derman, W., et al., *Illness and injury in athletes during the competition period at the London 2012 Paralympic Games: development and implementation of a web-based surveillance system (WEB-IISS) for team medical staff*. Br J Sports Med, 2013. **47**(7): p. 420-5.
13. Theron, N., et al., *Illness and injuries in elite football players--a prospective cohort study during the FIFA Confederations Cup 2009*. Clin J Sport Med, 2013. **23**(5): p. 379-83.
14. Mountjoy, M., et al., *Sports injuries and illnesses in the 2009 FINA World Championships (Aquatics)*. Br J Sports Med, 2010. **44**(7): p. 522-7.
15. Alonso, J.-M., et al., *Determination of future prevention strategies in elite track and field: analysis of Daegu 2011 IAAF Championships injuries and illnesses surveillance*. British Journal of Sports Medicine, 2012. **46**(7): p. 505-514.
16. Alonso, J.M., et al., *Occurrence of injuries and illnesses during the 2009 IAAF World Athletics Championships*. Br J Sports Med, 2010. **44**(15): p. 1100-5.
17. Engebretsen, L., et al., *Sports injuries and illnesses during the London Summer Olympic Games 2012*. British Journal of Sports Medicine, 2013. **47**(7): p. 407-414.
18. Al-Shaqsi, S., et al., *Sports injuries and illnesses during the second Asian Beach Games*. Br J Sports Med, 2012. **46**(11): p. 780-7.
19. Engebretsen, L., et al., *Sports injuries and illnesses during the Winter Olympic Games 2010*. Br J Sports Med, 2010. **44**(11): p. 772-80.
20. Soligard, T., et al., *Sports injuries and illnesses in the Sochi 2014 Olympic Winter Games*. British Journal of Sports Medicine, 2015.
21. Schwellnus, M., et al., *Factors associated with illness in athletes participating in the London 2012 Paralympic Games: a prospective cohort study involving 49,910 athlete-days*. Br J Sports Med, 2013. **47**(7): p. 433-40.
22. Boulet, L.P., *Cough and upper airway disorders in elite athletes: a critical review*. Br J Sports Med, 2012. **46**(6): p. 417-21.

23. Fitzgerald, L., *Overtraining increases the susceptibility to infection*. Int J Sports Med, 1991. **12 Suppl 1**: p. S5-8.
24. Hanley, D.F., *Medical care of the US Olympic Team*. JAMA, 1976. **236**(2): p. 147-8.
25. Jokl, E., *The immunological status of athletes*. J Sports Med Phys Fitness, 1974. **14**(3): p. 165-7.
26. Reeser, J.C., S. Willick, and M. Elstad, *Medical services provided at the Olympic Village polyclinic during the 2002 Salt Lake City Winter Games*. WMJ, 2003. **102**(4): p. 20-5.
27. Neville, V.J., et al., *Epidemiology of injuries and illnesses in America's Cup yacht racing*. British Journal of Sports Medicine, 2006. **40**(4): p. 304-312.
28. Palmer-Green, D. and N. Elliott, *Sports Injury and Illness Epidemiology: Great Britain Olympic Team (TeamGB) surveillance during the Sochi 2014 Winter Olympic Games*. British Journal of Sports Medicine, 2015. **49**(1): p. 25-29.
29. Weidner, T.G., *Literature review: upper respiratory illness and sport and exercise*. Int J Sports Med, 1994. **15**(1): p. 1-9.
30. Spence, L., et al., *Incidence, etiology, and symptomatology of upper respiratory illness in elite athletes*. Med Sci Sports Exerc, 2007. **39**(4): p. 577-86.
31. Wetterhall, S.F., et al., *Medical care delivery at the 1996 Olympic Games. Centers for Disease Control and Prevention Olympics Surveillance Unit*. JAMA, 1998. **279**(18): p. 1463-8.
32. Derman, W., *Medical care of the South African Olympic team-the Sydney 2000 experience*. South African Journal of Sports Medicine, 2003. **15**(3): p. 22-25.
33. Mountjoy, M., et al., *Competing with injuries: injuries prior to and during the 15th FINA World Championships 2013 (aquatics)*. Br J Sports Med, 2015. **49**(1): p. 37-43.
34. Tillett, E. and M. Loosemore, *Setting standards for the prevention and management of travellers' diarrhoea in elite athletes: an audit of one team during the Youth Commonwealth Games in India*. British Journal of Sports Medicine, 2009. **43**(13): p. 1045-1048.
35. Young, M., et al., *The travelling athlete: issues relating to the Commonwealth Games, Malaysia, 1998*. Br J Sports Med, 1998. **32**(1): p. 77-81.
36. Patel, D., *Occupational travel*. Occupational Medicine, 2011. **61**(1): p. 6-18.
37. Reid, D. and J.H. Cossar, *Epidemiology of travel*. Br Med Bull, 1993. **49**(2): p. 257-68.
38. Field, V., et al., *Travel and migration associated infectious diseases morbidity in Europe, 2008*. BMC Infectious Diseases, 2010. **10**(1): p. 330.
39. Reilly, T., et al., *Nutrition for travel*. J Sports Sci, 2007. **25 Suppl 1**: p. S125-34.
40. Price, C.J.S., T.J.W. Spalding, and C. McKenzie, *Patterns of illness and injury encountered in amateur ocean yacht racing: an analysis of the British Telecom Round the World Yacht Race 1996-1997*. British Journal of Sports Medicine, 2002. **36**(6): p. 457-462.
41. Hanstad, D.V., et al., *Fit for the fight? Illnesses in the Norwegian team in the Vancouver Olympic Games*. Br J Sports Med, 2011. **45**(7): p. 571-5.
42. Kippelen, P., et al., *Respiratory health of elite athletes – preventing airway injury: a critical review*. British Journal of Sports Medicine, 2012. **46**(7): p. 471-476.
43. Bergeron, M., et al., *International Olympic Committee consensus statement on thermoregulatory and altitude challenges for high-level athletes*. British Journal of Sports Medicine, 2012. **46**(11): p. 770-779.
44. Helenius, I., A. Lumme, and T. Haahtela, *Asthma, airway inflammation and treatment in elite athletes*. Sports Med, 2005. **35**(7): p. 565-74.
45. Vetvicka, J. and M. Handl, *Beijing 2008 olympic games meant danger for the health of athletes? Monitoring of air pollution during games of XXIX olympiade by PM10*. British Journal of Sports Medicine, 2011. **45**(4): p. 381.
46. Rundell, K.W., *Effect of air pollution on athlete health and performance*. British Journal of Sports Medicine, 2012. **46**(6): p. 407-412.
47. Rundell, K.W. and R. Caviston, *Ultrafine and fine particulate matter inhalation decreases exercise performance in healthy subjects*. J Strength Cond Res, 2008. **22**(1): p. 2-5.

48. Rundell, K.W., et al., *Decreased lung function after inhalation of ultrafine and fine particulate matter during exercise is related to decreased total nitrate in exhaled breath condensate*. *Inhalation toxicology*, 2008. **20**(1): p. 1-9.
49. Ruedl, G., et al., *Sport injuries and illnesses during the first Winter Youth Olympic Games 2012 in Innsbruck, Austria*. *Br J Sports Med*, 2012. **46**(15): p. 1030-7.
50. van Beijsterveldt, A.M.C., et al., *Sports injuries and illnesses during the European Youth Olympic Festival 2013*. *British Journal of Sports Medicine*, 2015. **49**(7): p. 448-452.
51. Meyer, N.L., et al., *Body composition for health and performance: a survey of body composition assessment practice carried out by the Ad Hoc Research Working Group on Body Composition, Health and Performance under the auspices of the IOC Medical Commission*. *British Journal of Sports Medicine*, 2013. **47**(16): p. 1044-1053.
52. Mountjoy, M., et al., *The IOC consensus statement: beyond the Female Athlete Triad--Relative Energy Deficiency in Sport (RED-S)*. *Br J Sports Med*, 2014. **48**(7): p. 491-7.
53. Humphries, D., *The biochemical basis of sports performance*. *British Journal of Sports Medicine*, 2006. **40**(7): p. 655-656.
54. Keast, D., K. Cameron, and A.R. Morton, *Exercise and the immune response*. *Sports Med*, 1988. **5**(4): p. 248-67.
55. Pedersen, B.K. and A.D. Toft, *Effects of exercise on lymphocytes and cytokines*. *British Journal of Sports Medicine*, 2000. **34**(4): p. 246-251.
56. Gleeson, M., et al., *Salivary IgA subclasses and infection risk in elite swimmers*. *Immunol Cell Biol*, 1999. **77**(4): p. 351-5.
57. Gleeson, M. and D.B. Pyne, *Special feature for the Olympics: effects of exercise on the immune system: exercise effects on mucosal immunity*. *Immunol Cell Biol*, 2000. **78**(5): p. 536-44.
58. Close, P., V. Thielen, and T. Bury, [*Mucosal immunity in elite athletes*]. *Rev Med Liege*, 2003. **58**(9): p. 548-53.
59. Tuan, T.-C., et al., *Deleterious effects of short-term, high-intensity exercise on immune function: evidence from leucocyte mitochondrial alterations and apoptosis*. *British Journal of Sports Medicine*, 2008. **42**(1): p. 11-15.
60. Albers, R., et al., *Markers to measure immunomodulation in human nutrition intervention studies*. *Br J Nutr*, 2005. **94**(3): p. 452-81.
61. Gunzer, W., M. Konrad, and E. Pail, *Exercise-induced immunodepression in endurance athletes and nutritional intervention with carbohydrate, protein and fat-what is possible, what is not?* *Nutrients*, 2012. **4**(9): p. 1187-212.
62. Brenner, I.K., P.N. Shek, and R.J. Shephard, *Infection in athletes*. *Sports Med*, 1994. **17**(2): p. 86-107.
63. Bermon, S., *Airway inflammation and upper respiratory tract infection in athletes: is there a link?* *Exerc Immunol Rev*, 2007. **13**: p. 6-14.
64. Pyne, D.B. and M. Gleeson, *Effects of intensive exercise training on immunity in athletes*. *Int J Sports Med*, 1998. **19 Suppl 3**: p. S183-91; discussion S191-4.
65. Budgett, R., *Overtraining syndrome*. *British Journal of Sports Medicine*, 1990. **24**(4): p. 231-236.
66. Lim, H.C., et al., *The influenza A (H1N1-2009) experience at the inaugural Asian Youth Games Singapore 2009: mass gathering during a developing pandemic*. *British Journal of Sports Medicine*, 2010. **44**(7): p. 528-532.
67. Del Giacco, S.R., P.E. Manconi, and G.S. Del Giacco, *Allergy and sports*. *Allergy*, 2001. **56**(3): p. 215-223.
68. Helenius, I.J., et al., *Asthma and increased bronchial responsiveness in elite athletes: atopy and sport event as risk factors*. *J Allergy Clin Immunol*, 1998. **101**(5): p. 646-52.
69. Katelaris, C.H., *Allergy and athletes*. *Curr Allergy Asthma Rep*, 2001. **1**(5): p. 397-8.
70. Nehlsen-Cannarella, S.L., et al., *Saliva immunoglobulins in elite women rowers*. *European Journal of Applied Physiology*, 2000. **81**(3): p. 222-228.

71. Helenius, I.J., et al., *Asthma and increased bronchial responsiveness in elite athletes: Atopy and sport event as risk factors*. Journal of Allergy and Clinical Immunology. **101**(5): p. 646-652.
72. Tscholl, P., et al., *The Use of Drugs and Nutritional Supplements in Top-Level Track and Field Athletes*. The American Journal of Sports Medicine, 2010. **38**(1): p. 133-140.
73. Tscholl, P.M., et al., *High prevalence of medication use in professional football tournaments including the World Cups between 2002 and 2014: a narrative review with a focus on NSAIDs*. British Journal of Sports Medicine, 2015. **49**(9): p. 580-582.
74. Gleeson, M., D.C. Nieman, and B.K. Pedersen, *Exercise, nutrition and immune function*. J Sports Sci, 2004. **22**(1): p. 115-25.
75. Sundgot-Borgen, J., et al., *How to minimise the health risks to athletes who compete in weight-sensitive sports review and position statement on behalf of the Ad Hoc Research Working Group on Body Composition, Health and Performance, under the auspices of the IOC Medical Commission*. British Journal of Sports Medicine, 2013. **47**(16): p. 1012-1022.
76. Loucks, A.B., B. Kiens, and H.H. Wright, *Energy availability in athletes*. Journal of Sports Sciences, 2011. **29**(sup1): p. S7-S15.
77. Hagmar, M., et al., *Special attention to the weight-control strategies employed by Olympic athletes striving for leanness is required*. Clinical Journal of Sport Medicine, 2008. **18**(1): p. 5-9.
78. Mountjoy, M., et al., *The IOC consensus statement: beyond the Female Athlete Triad—Relative Energy Deficiency in Sport (RED-S)*. British Journal of Sports Medicine, 2014. **48**(7): p. 491-497.
79. Burke, L., *Fasting and recovery from exercise*. British Journal of Sports Medicine, 2010. **44**(7): p. 502-508.
80. Venkatraman, J.T., X. Feng, and D. Pendergast, *Effects of dietary fat and endurance exercise on plasma cortisol, prostaglandin E2, interferon-gamma and lipid peroxides in runners*. J Am Coll Nutr, 2001. **20**(5): p. 529-36.
81. Russell, M., et al., *DIETARY ANALYSIS OF REGIONAL AND NATIONAL LEVEL YOUTH SWIMMERS IN THE UNITED KINGDOM*. British Journal of Sports Medicine, 2013. **47**(17): p. e4.
82. Grievink, L., et al., *Acute effects of ozone on pulmonary function of cyclists receiving antioxidant supplements*. Occupational and Environmental Medicine, 1998. **55**(1): p. 13-17.
83. Edouard, P., et al., *Analyses of Helsinki 2012 European Athletics Championships injury and illness surveillance to discuss elite athletes risk factors*. Clin J Sport Med, 2014. **24**(5): p. 409-15.
84. Peters, E.M. and E.D. Bateman, *Ultramarathon running and upper respiratory tract infections. An epidemiological survey*. S Afr Med J, 1983. **64**(15): p. 582-4.
85. Gleeson, M., *Mucosal immunity and respiratory illness in elite athletes*. Int J Sports Med, 2000. **21 Suppl 1**: p. S33-43.
86. Nieman, D.C., *Is infection risk linked to exercise workload?* Med Sci Sports Exerc, 2000. **32**(7 Suppl): p. S406-11.
87. Cox, A.J., et al., *Cytokine gene polymorphisms and risk for upper respiratory symptoms in highly-trained athletes*. Exerc Immunol Rev, 2010. **16**: p. 8-21.
88. Carlsen, K.-H., E. Hem, and T. Stensrud, *Asthma in adolescent athletes*. British Journal of Sports Medicine, 2011. **45**(16): p. 1266-1271.
89. Cox, A.J., et al., *Oral administration of the probiotic Lactobacillus fermentum VRI-003 and mucosal immunity in endurance athletes*. British Journal of Sports Medicine, 2010. **44**(4): p. 222-226.
90. Mier-Jedrzejowicz, A., C. Brophy, and M. Green, *Respiratory muscle weakness during upper respiratory tract infections*. Am Rev Respir Dis, 1988. **138**(1): p. 5-7.
91. Young, M., *What athletes often ask. Should I train when I have a cold and if not when can I return?* Br J Sports Med, 1998. **32**(1): p. 84.

Appendices

Appendix A: Participant Information Sheet

Team: _____

Player n^o: _____



University

Of

Cape Town

PLAYER MEDICAL QUESTIONNAIRE

2010 SUPER 14

ILLNESS RESEARCH STUDY

This questionnaire has been constructed by the Medical Research team. The information obtained from these questionnaires is essential for the planning of medical care during events such as future Super 14 competitions. We acknowledge that completion of the questionnaires may take some time and we appreciate your valuable time to complete this questionnaire in the 7 day period just before the start of 2010 Super 14 Rugby tournament.

The completion of the questionnaires is voluntary; all the information will be kept confidential and will only be used for research and medical care planning purposes.

Prof Martin Schwellnus

Player information and instructions

Please read the study information and then sign the Informed Consent section on the third page if you agree to participate in this research study.

Please complete the questionnaire with the help of your team doctor in the 7 day period before the start of the 2010 Super 14 Rugby tournament.

Please answer each question in Sections A to E of the questionnaire by filling in the details in the allocated space or checking one or more of the option boxes.

Please hand the forms to your team doctor, who will be asked to submit the completed forms to the University of Cape Town Research Office.

STUDY INFORMATION AND INFORMED CONSENT

- | | |
|-----------|--|
| Section A | Basic Details |
| Section B | Training History |
| Section C | History of Medication and Supplement Use as well as Lifestyle and Habits History |
| Section D | Family Medical History |
| Section E | General Personal Medical History |

University of Cape Town Research Ethics approval number: REC REF: 004/2010

STUDY INFORMATION AND INFORMED CONSENT

A research study will be conducted to determine how common medical conditions and illness are in players who participate in the 2010 Super 14 Rugby tournament in February to May 2010. This tournament will be held at venues in South Africa, New Zealand and Australia. The detailed information on each of the components of the study is as follows:

The purpose of this study is to determine how common a variety of medical conditions and illness are in rugby players during the tournament. For example, it is known that athletes, who train hard and then participate in strenuous competition, have increased respiratory tract symptoms (runny nose, sore throat, sinusitis, enlarged lymph glands in the neck, and even cough and chest pain with fever and headaches). However, these symptoms may not always be due to an infection but could be as a result of allergies or pollution. It has also been shown that apart from respiratory tract illness, other illnesses are very most common during competitions such as at the Olympic Games. These illnesses include gastro-intestinal symptoms, allergies, skin conditions, and other infections. These patterns of illness have not been studied in rugby players, particularly during competitions.

You will be given an opportunity to participate in a study where this will be investigated in rugby players. In the period prior to the competition, the UCT Research Office will provide your team doctor with all the information regarding the study. Your team doctor will then give you information about the study. You will then be given the opportunity to volunteer to participate in the study.

The details of the study are as follows:

- Your team doctor will give you a medical questionnaire that can be completed with the team doctor. This medical questionnaire will be anonymous and only a coding system will be used to identify your team. Your personal details will not be on the form. The questionnaire deals with training information and medical information.
- At the time of the competition, your team doctor will ask you every day about possible medical conditions and injuries. This information will be recorded anonymously on a sheet which will be sent to the investigators. If you suffer from any injury or disease/condition, your team doctor will treat it in the usual fashion.

Potential risks of this study

- The completion of a questionnaire is not associated with any risk. Questionnaire and other clinical data (paper and electronic) will be kept confidential, will be kept secure, and will not be made available to any party other than the research team without the consent of the individual participants.
- All medical conditions will be treated by the team doctor.

Potential benefits of this study

- The anticipated benefits of this study are that the results will further our understanding of the possible cause/s of medical conditions in rugby players that travel to participate in international competitions.

As a participant in the 2010 Super 14 Rugby tournament, you are given the choice to participate in this research effort. Your participation is entirely voluntary. Please read through the details of the study. The details of the study are explained in this document, and if you wish to participate in the study, please read through and sign the INFORMED CONSENT FORM on the next page. Please feel free to contact your team doctor, the UCT Research Office or members of the research team should you have any questions related to the study. Your team doctor has the contact details of the UCT Research Office and the research team. You can also call the following number of the principle investigator Prof Martin Schwellnus (+27-83-4543783) or co-investigator Prof Wayne Derman (+27-83-4543784)

University of Cape Town Research Ethics approval number: REC REF: 004/2010

I understand that a study will be conducted by the UCT/MRC Research Unit for Exercise Science and Sports Medicine (University of Cape Town):

“Illness In Elite Rugby Players During The 2010 Super 14 Rugby tournament: A Pilot Study“

I understand that my participation in this research project has no direct benefits to me during the 2010 Super 14 Rugby tournament. However, I understand that my participation in the research project will advance the medical and scientific knowledge related to rugby. Therefore, information gathered through my participation in this project could advance the future medical care, training advice and performance of rugby players.

I have read the study information and understand that the study involves the following components:

Completion of a medical questionnaire before the tournament:

The questionnaire will not contain any personal particulars (name, contact details). The completion of the questionnaire is not associated with any risk. All the questionnaire data and other clinical data (paper and electronic) will be kept confidential, will be kept secure, and will not be made available to any party other than the research team without the consent of the individual subjects.

I agree that all the information, which will be collected by my team doctor before the tournament, may be used to answer scientific questions about the medical conditions associated with the participation in and completion of a rugby tournament.

Daily information during the rugby tournament

I agree that all the information, which will be collected by my team doctor on a daily basis during the tournament, may be used to answer scientific questions about the medical conditions and injuries that are associated with the participation in and completion of a rugby tournament.

I have read (or, where appropriate, have had read to me) and understood the information about this study, and any questions I have asked have been answered to my satisfaction. I agree to participate in the study. I agree that research data provided by me or with my permission during the study may be included in a thesis, presented at conferences and published in journals on the condition that neither my name nor any other identifying information is used.

I have read the preceding subject information sheet and understand the testing procedures outlined therein and I hereby consent to participate in this study. I understand that I may withdraw from this study at any time without further question. I have been informed that the individual data derived from my participation in these protocols will remain confidential. I understand that the medical staff and the research team have professional medical insurance.

Player accreditation number:		Name of the team doctor:	
Signature of the player		Signature of the team doctor:	
Date:		Date:	
Name of the investigator:	Signature of the Investigator:	Date:	

University of Cape Town Research Ethics approval number: REC REF: 004/2010

Section A: Basic player details			
Team			
Player number			
Height			
Weight	cm		
Dominant Hand	kg	Age (on first day of competition)	yrs
Player position	Left <input type="checkbox"/> Right <input type="checkbox"/> Both <input type="checkbox"/>	Dominant Leg	Left <input type="checkbox"/> Right <input type="checkbox"/> Both <input type="checkbox"/>

Section B. Training history	
On average, how many days a week did you train during 15 weeks before the competition (from 1st November 2009)?	days/wk
On average, how many hours a week did you train in an average week during the 15 weeks before the competition (from 1st November 2009)?	hrs/wk
<p>Please indicate what types of training you perform and the percentage of training during 15 weeks before the competition (from 1st November 2009)?</p>	<input type="checkbox"/> Rugby training on the pitch ___ % <input type="checkbox"/> Strength training in a gymnasium ___ % <input type="checkbox"/> Endurance training (running, jogging, cycling) ___ % <input type="checkbox"/> Flexibility / agility training ___ % <input type="checkbox"/> Other training _____ ___ %
On average, how many days a week did you train during 2 weeks before the competition (from 1 February 2010)?	days/wk
On average, how many hours a week did you train in an average week during the 2 weeks before the competition (from 1 February 2010)?	hrs/wk

<p>Please indicate what types of training you perform and the percentage of training during 2 weeks before the competition?</p>	<p><input type="checkbox"/> Rugby training on the pitch ___ %</p> <p><input type="checkbox"/> Strength training in a gymnasium ___ %</p> <p><input type="checkbox"/> Endurance training (running, jogging, cycling) ___ %</p> <p><input type="checkbox"/> Flexibility / agility training ___ %</p> <p><input type="checkbox"/> Other training _____ ___ %</p>
<p>How did your training commitment affect your social life?</p>	<p><input type="checkbox"/> Not at all</p> <p><input type="checkbox"/> A fair amount</p> <p><input type="checkbox"/> A lot</p>

Section C. History of medication and supplement use			
What medication, if any, are you currently using? (please list)	Name of medication		Years taken
Are you currently taking dietary supplements/vitamins?			Yes <input type="checkbox"/> No <input type="checkbox"/>
If yes to the above question, please list names of dietary, sports or vitamin supplements.	Name of supplement		Years taken
	<input type="checkbox"/> Multi-vitamins		_____
	<input type="checkbox"/> Anti-oxidants		_____
	<input type="checkbox"/> Immune boosters		_____
	<input type="checkbox"/> Protein powders/supplements, Protein bars. BCAAs _____		
	<input type="checkbox"/> Creatine		_____
	<input type="checkbox"/> Caffeine		_____
	<input type="checkbox"/> Fat cutters		_____
<input type="checkbox"/> Carbohydrate drinks/powders/gels _____			
<input type="checkbox"/> Other: _____ _____			
Lifestyle and habits history			
Please indicate your smoking status		Current smoker <input type="checkbox"/>	Ex smoker <input type="checkbox"/> Never smoked <input type="checkbox"/>
If you answered yes, (past or current smoker) please complete the section on the right	Number of years of smoking:	If stopped, how many years ago:	
	What is (was) the average number of cigarettes per day:		

On average, how much alcohol do you drink per week (tots, glasses) of spirits, wine or beer?

_____ glasses beer/cider per week

_____ glasses wine per week

_____ tots of spirits per week

Section D. Family medical history

Have any of your blood (biological) relatives ever had the following?

Please tick yes or no. If yes, please tick the relationship of that person to you (You may tick more than one of the relationship blocks).

Description		If Yes, please indicate the relationship
Asthma	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/> Father <input type="checkbox"/> Mother <input type="checkbox"/> Brother <input type="checkbox"/> Sister <input type="checkbox"/> Child <input type="checkbox"/> Grandfather <input type="checkbox"/> Grandmother
Allergies (in general)	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/> Father <input type="checkbox"/> Mother <input type="checkbox"/> Brother <input type="checkbox"/> Sister <input type="checkbox"/> Child <input type="checkbox"/> Grandfather <input type="checkbox"/> Grandmother

Section E. General personal medical history

In this section, you are asked to read through **8 questions** about your personal general medical history. If you answer “yes” to any of questions, please complete the additional questions about that symptom/condition.

Question 1: Please indicate if you had any of the following immunizations

Influenza (H1N1) <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Measles / Mumps / Rubella <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Chicken Pox (Varicella) <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Meningitis (Menimune/Menactra) <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Hepatitis A (2 injections) <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Tetanus / Diptheria <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Hepatitis B (3 injections) <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yellow fever <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Other immunizations? Yes <input type="checkbox"/> No <input type="checkbox"/> Please give details:			
Are you taking malaria prophylaxis (tablets) Yes <input type="checkbox"/> No <input type="checkbox"/>		If yes, which tablets:	

Question 2: Recent close contact with individuals who had “flu” symptoms

(fever, sore throat, blocked or runny nose, cough, wheeze, muscle aches and pains)

2a. In the 6 weeks before the competition (from 1st January 2010) did you have any close contact (body contact, hand shakes, close spaces where coughing and sneezing occurred < 1 meter from you) with individuals who suffered from any symptoms of flu?	Yes <input type="checkbox"/> No <input type="checkbox"/>
2b. In the last week before the competition (from 4th February 2010) did you have any close contact (body contact, hand shakes, close spaces where coughing and sneezing occurred < 1 meter from you) with individuals who suffered from any symptoms of flu?	Yes <input type="checkbox"/> No <input type="checkbox"/>

Question 3: Flu symptoms in the last week before the competition (from 4th February 2010)

3a. In the last week (from 4th February 2010) before the competition did you suffer from any symptoms of flu (fever, sore throat, blocked or runny nose, cough, wheeze, muscle aches and pains)?	Yes <input type="checkbox"/> No <input type="checkbox"/>
--	---

If you answered **NO** to **question 3a** – Please go to **Question 4** below

If you answered **YES** to **question 3b** - please complete the following additional questions

<p>(3b) Please tick which of these flu symptoms you suffered from <u>in the last week</u>.</p>	<input type="checkbox"/> Fever <input type="checkbox"/> Cough <input type="checkbox"/> Joint pains <input type="checkbox"/> Blocked nose <input type="checkbox"/> Wheezing <input type="checkbox"/> Sore Throat <input type="checkbox"/> Runny nose <input type="checkbox"/> Muscle aches <input type="checkbox"/> Any other flu symptoms (Specify: _____)
---	--

Question 4: Flu symptoms in the 6 weeks before the competition
(from 1st January 2010)

<p>4a. In the <u>last 6 weeks (from the 1st January 2010) before the competition</u> (did you suffer from any <u>symptoms of flu</u> (fever, sore throat, blocked or runny nose, cough, wheeze, muscle aches and pains)?)</p>	Yes <input type="checkbox"/> No <input type="checkbox"/>
---	---

If you answered **NO** to **question 4a** – Please go to **Question 5** below

If you answered **YES** to **question 4a** - please complete the following additional questions

<p>(4b) Please tick which of these flu symptoms you suffered from <u>in the last 6 weeks</u>.</p>	<input type="checkbox"/> Fever <input type="checkbox"/> Cough <input type="checkbox"/> Joint pains <input type="checkbox"/> Blocked nose <input type="checkbox"/> Wheezing <input type="checkbox"/> Sore Throat <input type="checkbox"/> Runny nose <input type="checkbox"/> Muscle aches <input type="checkbox"/> Any other flu symptoms (Specify: _____)
--	--

Question 5: History of allergy symptoms

<p>5a. Have you <u>ever</u> in your rugby career suffered from <u>symptoms of allergies</u> including nose allergies (hay fever), allergic sinusitis, allergic asthma, skin allergies, a past history of allergies to medication, plant material or animal material?</p>	Yes <input type="checkbox"/> No <input type="checkbox"/>
--	---

If you answered **NO** to **question 5a** – Please go to **Question 6** below

If you answered **YES** to **question 5a** - please complete the following Table

<p>5b. Please indicate how long (years) have you been suffering from allergies?</p>	_____ years				
<p>5c. Please tick which <u>type of allergy</u> do you <u>currently suffer</u> from</p>					
Nose (hay fever)	Yes <input type="checkbox"/> No <input type="checkbox"/>	Sinusitis	Yes <input type="checkbox"/> No <input type="checkbox"/>	Asthma (allergic)	Yes <input type="checkbox"/> No <input type="checkbox"/>

Skin allergies	Yes <input type="checkbox"/> No <input type="checkbox"/>	Eye allergies	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to plant material	Yes <input type="checkbox"/> No <input type="checkbox"/>
Allergy to foods	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to animals	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to medication	Yes <input type="checkbox"/> No <input type="checkbox"/>
5d. Please tick which <u>type of allergy</u> do you <u>currently take medication</u> for					
Nose (hay fever)	Yes <input type="checkbox"/> No <input type="checkbox"/>	Sinusitis	Yes <input type="checkbox"/> No <input type="checkbox"/>	Asthma (allergic)	Yes <input type="checkbox"/> No <input type="checkbox"/>
Skin allergies	Yes <input type="checkbox"/> No <input type="checkbox"/>	Eye allergies	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to plant material	Yes <input type="checkbox"/> No <input type="checkbox"/>
Allergy to foods	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to animals	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to medication	Yes <input type="checkbox"/> No <input type="checkbox"/>
5e. Please tick which <u>type of medication</u> do you <u>currently take</u>					
Cortisone nose spray	Yes <input type="checkbox"/> No <input type="checkbox"/>	Cortisone nose inhaler	Yes <input type="checkbox"/> No <input type="checkbox"/>	Anti-histamine tablets	Yes <input type="checkbox"/> No <input type="checkbox"/>
Cortisone cream	Yes <input type="checkbox"/> No <input type="checkbox"/>	Anti-histamine cream	Yes <input type="checkbox"/> No <input type="checkbox"/>	Other inhaler / tablets or cream	Yes <input type="checkbox"/> No <input type="checkbox"/>
5f. Please tick which <u>symptoms of allergy</u> do you <u>currently suffer</u> from					
Sneezing	Yes <input type="checkbox"/> No <input type="checkbox"/>	Itchy runny nose	Yes <input type="checkbox"/> No <input type="checkbox"/>	Headache	Yes <input type="checkbox"/> No <input type="checkbox"/>
Itchy palate	Yes <input type="checkbox"/> No <input type="checkbox"/>	Streaming eyes	Yes <input type="checkbox"/> No <input type="checkbox"/>	Fatigue	Yes <input type="checkbox"/> No <input type="checkbox"/>
Itchy eyes	Yes <input type="checkbox"/> No <input type="checkbox"/>	Blocked nose	Yes <input type="checkbox"/> No <input type="checkbox"/>	Poor sleep	Yes <input type="checkbox"/> No <input type="checkbox"/>
Post nasal drip	Yes <input type="checkbox"/> No <input type="checkbox"/>	Coughing	Yes <input type="checkbox"/> No <input type="checkbox"/>	Wheezing	Yes <input type="checkbox"/> No <input type="checkbox"/>
In which months of the year do you <u>currently</u> have symptoms of allergies? (You tick more than one)	<input type="checkbox"/> Jan <input type="checkbox"/> Feb <input type="checkbox"/> March <input type="checkbox"/> April <input type="checkbox"/> May <input type="checkbox"/> June <input type="checkbox"/> July <input type="checkbox"/> Aug <input type="checkbox"/> Sept <input type="checkbox"/> Oct <input type="checkbox"/> Nov <input type="checkbox"/> Dec				

5g. Please tick which <u>type of allergy</u> did you suffer from <u>in the past (NOT currently)</u>					
Nose (hay fever)	Yes <input type="checkbox"/> No <input type="checkbox"/>	Sinusitis	Yes <input type="checkbox"/> No <input type="checkbox"/>	Asthma (allergic)	Yes <input type="checkbox"/> No <input type="checkbox"/>
Skin allergies	Yes <input type="checkbox"/> No <input type="checkbox"/>	Eye allergies	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to plant material	Yes <input type="checkbox"/> No <input type="checkbox"/>
Allergy to foods	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to animals	Yes <input type="checkbox"/> No <input type="checkbox"/>	Allergy to medication	Yes <input type="checkbox"/> No <input type="checkbox"/>

<u>Question 6: History of asthma</u>	
6a. Do you currently suffer from asthma including exercise induced asthma, or symptoms of asthma such as shortness of breath, wheezing, or chronic coughing?	Yes <input type="checkbox"/> No <input type="checkbox"/>
If you answered NO to question 6a – Please go to Question 7 below If you answered YES to question 6a - please complete the following questions	
6b. How many years have you suffered from asthma?	(years)
6c. How was your asthma diagnosed?	<input type="checkbox"/> A doctor taking a history and performing an examination <input type="checkbox"/> Lung function test (blow test) but no exercise <input type="checkbox"/> Lung function test (blow test) before and after exercise <input type="checkbox"/> Metacholine challenge test <input type="checkbox"/> Eucapnic hyperventilation test (rebreathing test) <input type="checkbox"/> Other test (Specify: _____)
6d. Which type of asthma do you currently suffer from?	<input type="checkbox"/> Asthma that occurs at any time but <u>not during exercise</u> <input type="checkbox"/> Asthma that occurs at any time including during exercise <input type="checkbox"/> Asthma that <u>only</u> occurs <u>during exercise</u>

<p>6e. Please indicate how frequently do you currently experience the symptoms of asthma (shortness of breath, wheezing, coughing or coughing after exercise)?</p>	<p>Daytime symptoms (per week)</p> <p><input type="checkbox"/> < 2 / week <input type="checkbox"/> 2-4 / week <input type="checkbox"/> >4 / week <input type="checkbox"/> All the time</p> <p>Night time symptoms (per month)</p> <p><input type="checkbox"/> < 1 / month <input type="checkbox"/> 2-3 / month <input type="checkbox"/> ≥4 / month <input type="checkbox"/> All the time</p> <p>Exercise related symptoms (per 10 exercise sessions)</p> <p><input type="checkbox"/> <1 per 10 sessions <input type="checkbox"/> 2-3 per 10 sessions <input type="checkbox"/> ≥4 per 10 sessions</p>
<p>6f. Please indicate if you had symptoms of asthma that were severe enough to necessitate hospital admission in the last 12 months</p>	<p><input type="checkbox"/> No hospital admission for asthma in the last 12 months</p> <p><input type="checkbox"/> 1-2 hospital admissions for asthma in the last 12 months</p> <p><input type="checkbox"/> 3-4 hospital admissions for asthma in the last 12 months</p> <p><input type="checkbox"/> >4 hospital admissions for asthma in the last 12 months</p>
<p>6g. Which <u>symptoms of asthma</u> do you currently suffer from?</p>	<p><input type="checkbox"/> Wheezing <input type="checkbox"/> Dry cough <input type="checkbox"/> Shortness of breath</p> <p><input type="checkbox"/> Tight chest <input type="checkbox"/> Chest pain</p> <p><input type="checkbox"/> Other (Specify: _____)</p>

<p>6h. What medication do you currently use for your asthma? (you may tick more than one option)</p>	<p><input type="checkbox"/> Cortisone inhaler (e.g. Beclate, Becloforte, Becodisks, Becotide, Budeflam, Flixotide, Inflammide, Pulmicort, Qvar, etc)</p> <p><input type="checkbox"/> Salbutamol (bronchodilator) inhaler (e.g. Ventolin, Venteze, Vomax, Airomir, Asthavent etc.)</p> <p><input type="checkbox"/> Salmeterol (bronchodilator) inhaler (Serevent)</p> <p><input type="checkbox"/> Fenoterol (bronchodilator) inhaler (Berotec)</p> <p><input type="checkbox"/> Terbutaline (bronchodilator) inhaler (Bricanyl)</p> <p><input type="checkbox"/> Formoterol (bronchodilator) inhaler (e.g. Foradil, Foratec, Oxis)</p> <p><input type="checkbox"/> Ipratropium (bronchodilator) inhaler (Atrovent)</p> <p><input type="checkbox"/> Tiotropium (bronchodilator) inhaler (Spiriva)</p> <p><input type="checkbox"/> Combined cortisone and bronchodilator inhaler (e.g. Atrovent, Berodual, Combivent, Duolin, Duovent, Seretide, Symbicord)</p> <p><input type="checkbox"/> Cortisone tablets</p> <p><input type="checkbox"/> Bronchodilator tablets</p> <p><input type="checkbox"/> Leukotriene receptor antagonist tablets (e.g. Accolate, Singulair)</p> <p><input type="checkbox"/> Other inhaler</p> <p><input type="checkbox"/> Other medication (Specify: _____)</p>
<p>6i. When do you use your medication for your asthma?</p>	<p><input type="checkbox"/> Daily (irrespective of exercise) <input type="checkbox"/> Only before exercise</p> <p><input type="checkbox"/> Other (Specify: _____)</p>
<p>6j. How long before an exercise session do you use your medication for asthma?</p>	<p>min</p>
<p>6k. Have you obtained TUE (therapeutic use exemption forms) for your asthma medication?</p>	<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>

Question 7: History of muscle cramping during rugby

7a. Have you ever in your rugby career suffered from muscle cramping (painful, spontaneous, sustained spasm of a muscle) during or immediately (within 6 hours) after exercise (in training or competition)?	Yes <input type="checkbox"/> No <input type="checkbox"/>
If you answered NO to question 7a – Please go to Question 8 below If you answered YES to question 7a - please complete the following additional questions	
7b. For how many years have you suffered from cramping?	(years)
7c. Did you suffer from cramping during or after exercise in the last 12 months ?	Yes <input type="checkbox"/> No <input type="checkbox"/>
7d. With what type of training is your cramping associated (You can tick more than one form of exercise)?	<input type="checkbox"/> Rugby <input type="checkbox"/> Weight training <input type="checkbox"/> Running <input type="checkbox"/> Other
7e. In the last 10 matches or training sessions , how many times have you experienced cramping?	Matches: _____/10 Training sessions: _____/10
7f. What treatment/s have you had that successfully relieved an acute cramp? (can tick more than one)	<input type="checkbox"/> Stretching <input type="checkbox"/> Resting <input type="checkbox"/> Drinking fluid <input type="checkbox"/> Ice application <input type="checkbox"/> Massage <input type="checkbox"/> Magnesium <input type="checkbox"/> Salt (tablets or solution) <input type="checkbox"/> Other (Specify: _____)
7g. At what point in the competition or training session do you usually first experience cramping?	<input type="checkbox"/> First quarter <input type="checkbox"/> Second quarter <input type="checkbox"/> Third quarter <input type="checkbox"/> Fourth quarter <input type="checkbox"/> After the session <input type="checkbox"/> No pattern
7h. In which muscles do you usually cramp (please list the muscle by the one which cramps most frequently (as 1) and the others after that (2-4)?	<input type="checkbox"/> Calves <input type="checkbox"/> Hamstrings <input type="checkbox"/> Quadriceps (thigh) <input type="checkbox"/> Foot muscles <input type="checkbox"/> Other (Specify: _____)
7i. Have you ever suffered from cramping in your whole body (arms and legs)?	Yes <input type="checkbox"/> No <input type="checkbox"/>
7j. Have you ever been admitted to hospital following cramping?	Yes <input type="checkbox"/> No <input type="checkbox"/>
7k. Have you ever been confused or in a coma during or after a cramping episode?	Yes <input type="checkbox"/> No <input type="checkbox"/>

7l. Have you ever had " dark urine " in the 3 days following a cramping episode?		Yes <input type="checkbox"/> No <input type="checkbox"/>
7m. If you cramp, how long does the cramp usually last for (min)?		(minutes)
7n. If you cramp, how severe is the cramp usually? (please tick).		<input type="checkbox"/> Mild: < 5 minutes and you are able to continue exercising <input type="checkbox"/> Moderate: 5-15 minutes and you are able to continue exercising <input type="checkbox"/> Severe: >15 minutes or if you have to STOP exercising

Question 8: History gastro-intestinal symptoms during rugby			
8a. Have you ever in your rugby career suffered gastrointestinal symptoms during rugby including heartburn, nausea, vomiting, abdominal pain, urge to defecate (pass a stool), diarrhoea, or blood in the stools?			Yes <input type="checkbox"/> No <input type="checkbox"/>
If you answered NO to question 8a – Please go to Question 9 below If you answered YES to question 8a - please complete the following Table			
Symptom	Number of times you experienced the GIT symptom in the last 12 months (during rugby training or matches)	Number of times you experienced the GIT symptom in the last 10 matches (during rugby matches)	Please indicate the " severity " of the GIT symptom during training or playing rugby
Nausea			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Vomiting			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Heartburn			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby

Abdominal pain			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Urge to pass a stool (defecate)			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Diarrhoea			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Passing blood in the stool			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Please indicate if you previously suffered from or had any of the following (you may tick more than one)?			<input type="checkbox"/> History of heartburn <input type="checkbox"/> Gastroscopy <input type="checkbox"/> Ulcer (gastric, duodenal) <input type="checkbox"/> Irritable bowel syndrome <input type="checkbox"/> Allergy to milk products <input type="checkbox"/> Other past history of GIT disease

Question 9: History of nervous system symptoms during rugby

9a. Have you **ever** in your rugby career suffered from symptoms of the **nervous system** including exercise induced headaches, depression, anxiety, nerve tingling or loss of sensation?

Yes
No

If you answered **NO** to **question 9a** – Please go to **Question 10** below
If you answered **YES** to **question 9a** - please complete the following Table

Symptom	Number of times in the last 12 months <u>(during rugby training or matches)</u>	Number of times in last 10 races <u>(during rugby matches)</u>	Please indicate the “ severity ” of the symptom during training or playing rugby
Headaches			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Depression			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Anxiety			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Nerve tingling in the hands			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Loss of sensation in the hands			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Nerve tingling in the feet			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby
Loss of sensation in the feet			<input type="checkbox"/> Does not affect training or playing <input type="checkbox"/> Affects training/playing rugby (slow down or reduce time) <input type="checkbox"/> Prevents training/playing rugby

Question 10: Other medical history (tick only if the answer is “yes”)

<p>10a. Did you suffer from any <u>skin disease in the last year?</u></p>	<p>Skin infections: Yes <input type="checkbox"/> <input type="checkbox"/> Skin allergy: Yes <input type="checkbox"/> Sunburn: Yes <input type="checkbox"/></p>	<p>Skin cancer: Yes <input type="checkbox"/> Other skin damage resulting from sun exposure: Yes <input type="checkbox"/></p>
<p>10b. Did you suffer from any <u>blood disorder in the last year?</u></p>	<p>Anaemia: Yes <input type="checkbox"/> <input type="checkbox"/> Sickle cell trait: Yes <input type="checkbox"/> Bleeding disorder: Yes <input type="checkbox"/> Blood clot (thrombosis) Yes <input type="checkbox"/> Other blood disorder: Yes <input type="checkbox"/></p>	<p>Low iron stores: Yes <input type="checkbox"/> Sickle cell disease: Yes <input type="checkbox"/> Clotting disorder: Yes <input type="checkbox"/> Blood clot (embolus) Yes <input type="checkbox"/> Details:</p>
<p>10c. Did you suffer from any <u>immune system disorder in the last year?</u></p>	<p>Recurrent infections: Yes <input type="checkbox"/> Leukaemia: Yes <input type="checkbox"/></p>	<p>HIV/ AIDS: Yes <input type="checkbox"/> Other immune disorder: <input type="checkbox"/> Details:</p>
<p>10d. Did you suffer from any <u>kidney or bladder disease in the last year?</u></p>	<p>Blood in urine: Yes <input type="checkbox"/> Kidney stones: Yes <input type="checkbox"/> Burning urination: Yes <input type="checkbox"/> Other kidney disorder: Yes <input type="checkbox"/></p>	<p>Loin pain: Yes <input type="checkbox"/> Frequent urination: Yes <input type="checkbox"/> Bilharzia infection: Yes <input type="checkbox"/> Details:</p>
<p>10e. Did you suffer from any <u>metabolic or hormonal disease in the last year?</u></p>	<p>Diabetes mellitus: Yes <input type="checkbox"/> Other hormone or metabolic disease: Yes <input type="checkbox"/></p>	<p>Thyroid disease: Yes <input type="checkbox"/></p>
<p>10f. Did you suffer from any <u>symptoms (not related to an injury) of arthritis in the last year?</u></p>	<p>Joint pain: Yes <input type="checkbox"/> Joint redness: Yes <input type="checkbox"/> Gout: Yes <input type="checkbox"/></p>	<p>Joint swelling: Yes <input type="checkbox"/> Joint stiffness: Yes <input type="checkbox"/> Other joint disorder: Yes <input type="checkbox"/></p>
<p>10g. Were you born without, or are you <u>missing any organs?</u></p>	<p>Missing kidney: Yes <input type="checkbox"/> <input type="checkbox"/> Missing testicle: Yes <input type="checkbox"/> Gout: Yes <input type="checkbox"/></p>	<p>Missing eye: Yes <input type="checkbox"/> Other missing organs: Yes <input type="checkbox"/></p>
<p>10h. Do you have a history of an <u>injury to any vital internal organs?</u></p>	<p>Liver injury: Yes <input type="checkbox"/> <input type="checkbox"/> Spleen injury: Yes <input type="checkbox"/> Heart injury: Yes <input type="checkbox"/></p>	<p>Kidney injury: Yes <input type="checkbox"/> <input type="checkbox"/> Lung injury: Yes <input type="checkbox"/> Other organ injury: Yes <input type="checkbox"/></p>

10i. Do you have <u>any other medical problems</u> ? (please give details)	
--	--

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE!

Appendix B: Informed Consent Form

STUDY INFORMATION AND INFORMED CONSENT

A research study will be conducted to determine how common medical conditions and illness are in players who participate in the 2010 Super 14 Rugby tournament in February to May 2010. This tournament will be held at venues in South Africa, New Zealand and Australia. The detailed information on each of the components of the study is as follows:

The purpose of this study is to determine how common a variety of medical conditions and illness are in rugby players during the tournament. For example, it is known that athletes, who train hard and then participate in strenuous competition, have increased respiratory tract symptoms (runny nose, sore throat, sinusitis, enlarged lymph glands in the neck, and even cough and chest pain with fever and headaches). However, these symptoms may not always be due to an infection but could be as a result of allergies or pollution. It has also been shown that apart from respiratory tract illness, other illnesses are very most common during competitions such as at the Olympic Games. These illnesses include gastro-intestinal symptoms, allergies, skin conditions, and other infections. These patterns of illness have not been studied in rugby players, particularly during competitions.

You will be given an opportunity to participate in a study where this will be investigated in rugby players. In the period prior to the competition, the UCT Research Office will provide your team doctor with all the information regarding the study. Your team doctor will then give you information about the study. You will then be given the opportunity to volunteer to participate in the study.

The details of the study are as follows:

- Your team doctor will give you a medical questionnaire that can be completed with the team doctor. This medical questionnaire will be anonymous and only a coding system will be used to identify your team. Your personal details will not be on the form. The questionnaire deals with training information and medical information.
- At the time of the competition, your team doctor will ask you every day about possible medical conditions and injuries. This information will be recorded anonymously on a sheet which will be sent to the investigators. If you suffer from any injury or disease/condition, your team doctor will treat it in the usual fashion.

Potential risks of this study

- The completion of a questionnaire is not associated with any risk. Questionnaire and other clinical data (paper and electronic) will be kept confidential, will be kept secure, and will not be made available to any party other than the research team without the consent of the individual participants.
- All medical conditions will be treated by the team doctor.

Potential benefits of this study

- The anticipated benefits of this study are that the results will further our understanding of the possible cause/s of medical conditions in rugby players that travel to participate in international competitions.

As a participant in the 2010 Super 14 Rugby tournament, you are given the choice to participate in this research effort. Your participation is entirely voluntary. Please read through the details of the study. The details of the study are explained in this document, and if you wish to participate in the study, please read through and sign the INFORMED CONSENT FORM on the next page. Please feel free to contact your team doctor, the UCT Research Office or members of the research team should you have any questions related to the study. Your team doctor has the contact details of the UCT Research Office and the research team. You can also call the following number of the principle investigator Prof Martin Schweltnus (+27-83-4543783) or co-investigator Prof Wayne Derman (+27-83-4543784)

University of Cape Town Research Ethics approval number: REC REF 004/2010

I understand that a study will be conducted by the UCT/MRC Research Unit for Exercise Science and Sports Medicine (University of Cape Town):

“Illness In Elite Rugby Players During The 2010 Super 14 Rugby tournament: A Pilot Study“

I understand that my participation in this research project has no direct benefits to me during the 2010 Super 14 Rugby tournament. However, I understand that my participation in the research project will advance the medical and scientific knowledge related to rugby. Therefore, information gathered through my participation in this project could advance the future medical care, training advice and performance of rugby players.

I have read the study information and understand that the study involves the following components:

Completion of a medical questionnaire before the tournament:

The questionnaire will not contain any personal particulars (name, contact details). The completion of the questionnaire is not associated with any risk. All the questionnaire data and other clinical data (paper and electronic) will be kept confidential, will be kept secure, and will not be made available to any party other than the research team without the consent of the individual subjects.

I agree that the all the information, which will be collected by my team doctor before the tournament, may be used to answer scientific questions about the medical conditions associated with the participation in and completion of a rugby tournament.

Daily information during the rugby tournament


I agree that the all the information, which will be collected by my team doctor on a daily basis during the tournament, may be used to answer scientific questions about the medical conditions and injuries that are associated with the participation in and completion of a rugby tournament.

I have read (or, where appropriate, have had read to me) and understood the information about this study, and any questions I have asked have been answered to my satisfaction. I agree to participate in the study. I agree that research data provided by me or with my permission during the study may be included in a thesis, presented at conferences and published in journals on the condition that neither my name nor any other identifying information is used.

I have read the preceding subject information sheet and understand the testing procedures outlined therein and I hereby consent to participate in this study. I understand that I may withdraw from this study at any time without further question. I have been informed that the individual data derived from my participation in these protocols will remain confidential. I understand that the medical staff and the research team have professional medical insurance.

Player accreditation number:	Name of the team doctor:
Signature of the player	Signature of the team doctor:
Date:	Date:

Appendix C: Research Ethics Approval

 UNIVERSITY OF CAPE TOWN HUMAN RESEARCH ETHICS COMMITTEE		04 DEC 2013 Form FHS007: Amendment – study staff HEALTH SCIENCES FACULTY		FACULTY OF HEALTH SCIENCES Human Research Ethics Committee
HREC office use only (FWA00001937, IRB00001938)				
<input checked="" type="checkbox"/> Approved				
This serves as notification that all changes to the study staff and documentation described below are approved.				
Chairperson of the HREC signature			Date	
			4/12/2013	

Principal Investigator to complete the following:

1. Protocol information

Date	29 November 2013		
HREC REF Number	REC 004/2010		
Protocol title	Illness In Elite Rugby Players During The 2010 Super 14 Rugby Tournament: A Pilot Study		
Protocol number (if applicable)	N/A		
Principal Investigator	Prof Martin Schweltnus		
Department / Office Internal Mail Address	Human Biology		
1.1 Does this protocol receive US Federal funding?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No	

2. Items for approval

Please list on the page below all staff changes and additional documentation such as CVs and revised consent forms which need approval. This information must correspond to all 'yes' answers below. This page will be detached, signed and returned to the PI as notification of approval. Please add extra pages if necessary.

3. List of documentation (eg: CVs, Declarations & GCP Certificates)

Dr. Alan Kourie is added to the co-investigator list. He is an MPhil Sport and Exercise Medicine student and will explore a component of the data that have been collected during this study in 2010. In particular, he will investigate one of the secondary aims of this study, which is to document the risk factors that are associated with illness in rugby players who participated in the Super Rugby tournaments.

4. Staff changes (tick ✓)

Are new personnel being added to this research?	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
Are current personnel being removed from this research?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No

