An injury surveillance of patients utilising the Durban University of Technology (DUT) Chiropractic Treatment Facilities at the 2013 World Transplant Games

By

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This work is submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic at the Durban University of Technology

I, Michael John McBean, do declare that this dissertation is representative of my own work in both conception and execution

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Dedication

I dedicate this to each and every one of my future patients. I will endeavour to always treat you to the best of my abilities; continuously and relentlessly striving to ensure you are afforded the opportunity to experience health, by hand.

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First and foremost, I would like to thank my parents, Pat and Karen, for not only providing me the opportunity to study, but for supporting me the entire time. You have both taught me so much and helped me to become the person I am today.

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"What lies behind us, and what lies before us are small matters compared to what lies within us."

Ralph Waldo Emerson

Abstract

Background: The 19th Iteration of the World Transplant Games was hosted in Durban, South Africa in 2013. This biennial, international, multisport event showcases the talents of transplant athletes, whilst demonstrating the benefits of organ transplantation. To date, limited research is available on transplant athletes. This study aimed to determine the injury profile of transplant athletes who presented to the Durban University of Technology Chiropractic Treatment Facilities during the 2013 World Transplant Games.

Methods: This retrospective, descriptive cohort study analysed the data collected at the Chiropractic Treatment Facilities at the 2013 World Transplant Games. For inclusion, each WTG Form required completion, reflecting all the elements of that participant's chiropractic consultation. The data recorded on the World Transplant Games Form generated the data analysed in this study. The data described the frequency (frequency tables), nature and management of injuries treated at the Chiropractic Treatment Facilities during the 2013 World Transplant Games. In order to determine relationships cross tabulations were used.

Results: There were 964 athletes registered for the 2013 World Transplant Games, of which 153 presented to the Chiropractic Treatment Facilities (an utilisation rate of 15.9%). A total of 259 consultations by the athletes (n = 223; 86.1%) and non-athletes (n = 36; 13.9%) were recorded. The majority of the treated athletes were White (n = 91; 59.5%), males (n = 109; 71.2%), in which kidney transplant recipients accounted for 37.3% (n = 58) of the total number. Track athletics had the highest injury rate (34.5% of all reported injuries). Athletes sustained injuries to 14 different anatomical regions, with the thigh (26.9%) and shin/calf (20.5%) being the most frequently injured. The majority of injuries (n = 164; 66.4%) were "overuse" injuries, with myofasciitis, muscle strains and thoracic facet syndrome being the most frequently obtained diagnoses (25.5%, 16.6% and 6.5% respectively). The most frequently employed treatment modalities were those of massage (32.1%), ischemic compression (16.3%) and manipulation (13.4%). It was noted that the most injuries sustained (88.3%) were not severe enough to result in an inability to continue current or future participation.

Conclusions and Recommendations: Transplant recipient athletes injuries concur with the literature on non-transplant athletes, indicating that solid organ transplantation does not predispose the athlete to different or more serious injuries which would require different management protocols by health care personnel treating these athletes. Further investigation into individual sports is encouraged, to develop accurate, effective injury management and preventative strategies to more appropriately diagnose and treat injuries incurred by transplant athletes and then to prevent them from recurring. An informed healthcare approach towards event organising and athlete treatment will improve preventative strategies and athlete management.

Key Indexing Terms: *Transplant Athletes*; *Chiropractic; Athletic Injuries; Population Surveillance; Injury Profile*

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Definitions

Acute	Having a short and relatively severe course (Dorland, 2007).
Athlete	Generally, the definition of an athlete is given as a person who is proficient in sports and other forms of physical exercise (Oxford dictionaries, 2014). For the purposes of this study, an athlete referred specifically to any individual who actively took part in competition in at least one event at the 2013 WTG.
Calor	Latin term for: Heat (Rippey, 2006).
Chronic	Persisting over a long period of time (Dorland, 2007).
Consultation	For the purposes of this research a consultation was defined as any clinical interaction that occurred at the CTF at the WTG which was recorded on the WTG Form during the WTG.
Dolor	Latin term for: Pain (Rippey, 2006).
Functio Lasea	Latin term for: Loss of Function (Rippey, 2006).
Incidence	The rate at which a certain event occurs, as the number of new cases of a specific disease occurring during a specific period of time in a population at risk (Dorlands, 2007).
Injury	Any musculo-skeletal complaint newly incurred due to competition and/or training during the tournament that received medical attention regardless of the consequences with respect to absence from competition or training (Junge *et al.,* 2008).
Injury hazard	Instantaneous or mean proportion injured per unit of time (Hopkins *et al.,* 2007).
Injury rate	Number of injuries per unit of exposure time (Hopkins *et al.,* 2007).
Injury risk	Proportion of athletes injured in a given time period (Hopkins *et al.,* 2007).
Libero	Specialist defensive position in volleyball (Volleyball World Wide, 2015).
Management	The management plan includes the treatment of the area of complaint / injury (within the designated scope of practice of the practitioner) as well as

	addressing the overall health care of the athlete in order to ensure appropriate healing, recovery, rehabilitation and return to sport performance (Hyde and Gengenbach, 2007).
Odds of injury	Probability injury will occur divided by probability injury will not occur (Hopkins *et al.,* 2007).
Overuse injury	Overuse injuries occur due to repetitive sub maximal loading of the musculoskeletal system when rest is not adequate to allow for structural adaptation to take place (DiFiori *et al.,* 2014).
Participant	Any individual who was present at the 2013 WTG and voluntarily sought treatment at the CTF.
Prevalence	The number of cases of a specific disease in a given population at a specific time (Dorlands, 2007).
Rubor	Latin term for: Redness (Rippey, 2006).
Student and / or Chiropractic student	A 5th Year Chiropractic student currently enrolled at the Durban University of Technology, who worked at the 2013 WTG.
Subacute	Somewhat acute, between acute and chronic (Dorland, 2007).
Treatment	The treatment includes the combination of directed therapies / interventions (within the designated scope of practice of the practitioner) utilised to address a particular injury / area of complaint in a patient (Hyde and Gengenbach, 2007).
Tumor	Latin term for: Swelling (Rippey, 2006).

Abbreviations

AAG	All Africa Games
AC	Acromioclavicular
ACL	Anterior Cruciate Ligament
CAM	Complementary and Alternative Medicine
CSSA	Chiropractic Student Sports Association
CTF	Chiropractic Treatment Facilities
DOMS	Delayed Onset Muscle Soreness
DUT	Durban University of Technology
FICS	Federation Internationale de Chiropratique du Sport
IAAF	International Association of Athletics Federations
ICC	International Convention Centre
IOC	International Olympic Committee
Ischemic Comp	Ischemic Compression
ITB	Iliotibial Band
KZN	KwaZulu-Natal
LOC	Local Organising Committee
MSK	Musculoskeletal
MTSS	Medial Tibial Stress Syndrome
NCAA	National Collegiate Athletic Association
OG	Olympic Games
PNF	Proprioceptive Neuromuscular Facilitation
UKZN	University of KwaZulu-Natal
WG	World Games
WHO	World Health Organisation
WTG	World Transplant Games
WTGF	World Transplant Games Federation

CHAPTER ONE: INTRODUCTION

1.1 Introduction

This Chapter serves to introduce the study and outline the aims, objectives and limitations thereof.

1.2 The World Transplant Games

The first organised event for transplant recipients was hosted in Portsmouth, England, in 1978. The World Transplant Games Federation (WTGF) was officially formed in 1987 and became responsible for organising and hosting the Summer and Winter World Transplant Games (WTG). Since its official formation, the WTGF has grown to include nearly 70 member countries (World Transplant Games Federation, 2013).

With the advancements in modern medicine and the ever increasing knowledge of the benefit of sports participation for transplant recipients (Mosconi *et al.,* 2009), there has been an increase in the number of competing athletes at nationally organised events and subsequently at the WTG. When considering the adverse effects of transplantation, such as those highlighted by Schonder *et al.* (2010), Unterman, *et al.* (2009) and Diep *et al.* (2008) (steroid-induced diabetes, peripheral neuropathy, musculoskeletal pathology, infection and an increased risk of malignancy), it is important to ensure the correct management and treatments are received by those transplant recipients competing in major sporting events (Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008). This is further substantiated by the rapid professionalization of sporting codes in the modern era (Taylor and Garratt, 2008), including those represented at the WTG, which has maintained a high standard at the WTG (WTGF, 2014). Transplant athletes are now able to physically push themselves further, as a result of the advancements of transplantation procedures, immunosuppressive medication, nutrition and patient management practices (Cavayero and Kar, 2014).

The continued growth of the WTG, which today includes over 70 member countries means that there is an increased number of participating athletes – from 99 athletes in 1978 to 1900 in 2011 (WTGF, 2014). It is this increased participation which gives rise to a higher level of competitiveness amongst the athletes (Ljungqvist *et al.,* 2008; Gill, 1986).The increased level and degree of participation, coupled with the unique complications faced by transplant athletes require increased knowledge pertaining to transplant athletes, physical activity and the possible complications faced by them. This places increased demand and increased precision on athlete management practices, including the diagnosis and treatment of injuries that present and the prevention of recurrent and new injuries (Cavayero and Kar, 2014). This is of particular importance to the chiropractor, who is likely to deal with the musculoskeletal sequelae of sports participation by ordinary athletes (Hyde and Gengenbach, 2007) and transplant athletes. As a result it is important that the chiropractor is familiar with the needs of ordinary athletes (Hyde and Gengenbach, 2007) and transplant athletes (Cavayero and Kar, 2014) in order to better manage each of their respective requirements in injury management and injury prevention (Hyde and Gengenbach, 2007). However, due to the paucity of literature surrounding transplant athletes and their specific requirements, needs and injury presentation (Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008), it is important for research to consider whether transplant athletes have differing injury profiles based on their medical and physiological limitations (Cavayero and Kar, 2014; Schonder *et al.,* 2010). This research was therefore aimed at enabling practitioners, particularly chiropractors, to identify injuries appropriate to their mechanism (related to sporting code or the type of transplant and its sequelae) and treat them with such care as is most appropriate, effective and suitable at the time or direct them for urgent medical intervention.

Therefore this research project set out to ascertain the musculoskeletal injuries of WTG 2013 participants that presented themselves for treatment as documented through the CTF and determine whether specific injury profiles exist for different transplant athletes in relation to the sports they participated in.

1.3 Research Aims and Objectives

1.3.1 Aim

The aim of this study was to develop a retrospective cohort analysis of the injury profiles of athletes and non-athletes that presented to the Durban University of Technology (DUT) Chiropractic Treatment Facilities (CTF) during the 2013 WTG.

1.3.2 Objectives

The first objective of this study was to determine the number of consultations made by all athletes and non-athletes to all the DUT Chiropractic Treatment Facilities at the 2013 WTG.

The second objective was to develop an injury profile of the 2013 WTG in terms of: injury prevalence per sport or activity; anatomical area; causation of injury; treatment intervention and treatment frequency.

The third objective of this research was to determine the treatment profile used in the management of patients who presented to the DUT Chiropractic treatment facilities.

The fourth objective was to passively track each individual participant, who presented to the DUT Chiropractic Treatment Facilities, throughout the duration of the seven days of competition.

The objectives as listed above were established in order to answer the research question of this project, which was as follows: What is the profile of injuries among participants who made use of the Chiropractic treatment facilities at the 2013 WTG throughout the entire duration of the event?

1.4 Rationale

The majority of current literature on transplant athletes and the WTG focuses on issues of a medical nature (defined as those medical conditions that require assessment and medical intervention in order to curb mortality or to deal with the sequelae of medical intervention for the transplant received by the athlete) (Johnson *et al.,* 2013). Transplant athletes may, succumb to varying degrees of musculoskeletal (MSK) complications (Unterman, *et al.,* 2009; Diep *et al.,* 2008). These orthopaedic and musculoskeletal complaints or complications may occur due to the long periods of immobility, a decreased bone density (as a result of long term immunosuppressant use and renal insufficiency), an often long and stressful pre-transplantation period as well as a host of other known and unknown etiological causes (Lindsay, 2004; Fahrleitner *et al.,* 2002; Shane, *et al.,* 1997).

In a recent study conducted by Movassaghi *et al.,* (2012), it was shown that approximately forty percent of solid organ transplant recipients may develop musculoskeletal complaints, especially joint pain as a result of their transplant precedures. With frequent pre- and post-transplantation examination, these complications could be identified, treated and managed accordingly (Movassaghi *et al.,* 2012; Ramasamy, Hill and Clasper, 2009; Lindsay, 2004.), which may reduce the burden of disease (Dagenais *et al.,* 2008).

The rationale, then, of this research project was to determine and provide information regarding the demographics of injuries and/or neuromusculoskeletal complaints experienced by athletes and non-athletes at the 2013 WTG, who presented to the DUT Chiropractic Treatment Facilities (CTF). It is through the analysis of this above mentioned data that health care practitioners, especially manual therapists, such as chiropractors, biokineticists and physiotherapists, may be able to more appropriately diagnose, treat and manage sporting discipline related injuries and differentiate these from complications experienced by many transplant athletes (Ramasamy, Hill and Clasper, 2009). Without reliable health and injury information health care providers are in a handicapped, disadvantaged position (WHO, 2001), unable to provide the most appropriate care at the most appropriate time. This delay in care, particularly for transplant athletes, may have dire consequences (Ramasamy, Hill and Clasper, 2009). To avoid this, health care practitioners require the ability to access accurate information that will allow them to allocate resources to effectively ensure maximal impact when dealing with the prevention, treatment and rehabilitation of injuries (WHO, 2001). In addition to this, the information obtained from this study may prove to be beneficial for future event organisers and regulating bodies of transplant athletes, by allowing them to understand the injuries and illnesses with which transplant athletes are afflicted, and in so doing be appropriately prepared to offer these athletes adequate medical care (Finch and Cook, 2013; Junge *et al.,* 2008).

1.5 Limitations

This study was a retrospective study that analysed the clinical data recording sheets of participants who presented at the DUT CTF at the WTG. Only data from recording sheets (hereafter referred to as the WTG Forms), where the athletes indicated that they agreed to have the data collected at their consultation utilised for research purposes, were utilised. This agreement / consent for use of the information generated by their consultation, was indicated by the athletes signing the WTG Form. Each athlete had the right to decline the use of their information in future research studies. This did however not compromise their ability to receive care at the DUT CTF.

The WTG is an international competition, with participants from all around the world. This may have presented language barriers between the chiropractic students and the athlete. This may have resulted in difficulties in not only accurately recording data from the patient, but also explaining the possibility that data may be utilised in future research and gaining the permission from the athlete for this. Therefore any unsigned WTG Forms were excluded from this study on the premise that the athlete did not or was not able to provide consent for the information to be utilised for research purposes.

With this study being a retrospective analysis of the collected WTG Forms, it inherently relied on trained and supervised chiropractic fifth year students for capturing all the patients' demographic information as well as the diagnosis and subsequent treatment and management protocols, accurately and appropriately. This collection process was assumed to have been uniform and consistent among sites of data collection and between students and their supervising chiropractor. Notwithstanding this, it is noted that consideration is given to the fact that the data was recorded and completed by fifth year chiropractic students, albeit under the guidance and supervision of qualified chiropractors.

1.6 Conclusion

This chapter presented the fact that limited research exists pertaining to the use and/or role of chiropractic treatment specifically in transplant recipient athletes (Wootton and Sparber, 1999); however, there is evidence to suggest that regular physical activity combined with the correct management of any and all musculoskeletal complaints experienced by transplant recipients, can result in improved strength performance, endurance and quality of life (Kjaer *et al.,* 1999). There is currently no evidence to substantiate the use of chiropractic and other manual therapies in treating and managing transplant recipient athletes. The majority of published research pertaining to transplant athletes and the WTG has focused on issues of a medical nature (Johnson *et al.,* 2013) or on specific demands in relation to medical and physical exercise (Tomczak *et al.,* 2008), with little differentiation between musculoskeletal injuries / complaints requiring urgent medical attention to reduce morbidity or mortality and musculoskeletal injuries / complaints that can be addressed by manual therapists.

Further, there are only a limited number of surveillance studies that have been conducted and published regarding the utilisation of chiropractic care at national and international multisport events (Nook and Nook, 1997; Nook and Nook, 2011). With a cohort analysis of transplant patients never having been conducted before, it was therefore the aim of this study to develop a retrospective cohort analysis of the injury profiles of athletes and non-athletes that presented to the Durban University of Technology (DUT) Chiropractic treatment facilities (CTF) during the 2013 WTG.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Chapter Two provides an overview of the current literature regarding transplant athletes, in order to add to the reader's understanding of the rationale behind, and importance of studying, the injury profiles of those individuals who participated in the 2013 WTG. This Chapter provides a definition of transplantation and also provides additional information regarding sports participation and transplant athletes.

2.1.1 The World Transplant Games

The first competitive sporting event specifically organised for transplant athletes was hosted in Portsmouth, England in 1978. The event attracted approximately 99 competitors from the countries of Germany, Greece, France, The United Kingdom and The United States of America (History of the Games, 2014)

Today, the World Transplant Games Federation (WTGF) hosts the Summer WTG every two years with the Winter WTG being held in each intervening year. The summer games hosted in Gothenburg in 2011 saw an increase in both support and participation, with 50 countries being represented by almost 1900 participant athletes, support staff, donors and donor family members. Entrance into and permission to participate in the WTG is strictly controlled and monitored by the WTGF Medical Committee (Rules for the Sports of the 2013 World Transplant Games, 2012). In order for an athlete to be allowed to participate in the WTG, the following criteria must be met:

1. Entry is open to all recipients of life supporting allografts and hematopoietic cell transplants from other individuals (living or deceased) or species which require or have required the use of immunosuppressive drug therapies.
2. All competitors must have been transplanted for at least a one year period, with stable graft function, be medically fit and have trained / practiced in the events in which they have entered.
3. If a potential competitor has been transplanted for a period of more than six months but less than one year, his or her entry may be considered by the WTGF Medical Committee; as long as the patient displays stable graft

function, the patient has been training and the patient has permission from his or her own doctor to participate.

Once accepted for participation, the 2013 WTG participant was able to participate in any one or more of the following sports and events: Badminton, Cycling, Golf, Lawn Bowls, Petanque, 5Km Road Race, Squash, Swimming, Table Tennis, Ten Pin Bowling, Tennis, Track and Field and lastly Volleyball. Each of the sports are subject to its own rules and regulations as determined by the governing body for that particular sport, specifics of which are defined for each sport in Section 2.2.

2.1.2 Athlete

The definition of an athlete is constantly changing and evolving and is currently stated as being a person who is proficient in sports and other forms of physical exercise (Oxford Dictionaries, 2014) and who participates in these activities on a regular basis (Robergs and Roberts, 1996). Therefore an athlete is an individual who is trained in or good at sports, games, or exercises that require physical skill and strength (Hyde and Gengenbach, 2007). Whilst the definition of an athlete may be an evolving concept it is essential that an understanding of the physiological, biological and psychological effects that may befall an athlete during athletic activity are known (Hyde and Gengenbach, 2007). It is only through the knowledge of these adverse and/or positive effects, that we as health care practitioners, tasked with managing and treating athletes, may be able to better serve these individuals and allow them a longer participation opportunity (Hyde and Gengenbach, 2007; Pecina and Bojanic, 2003).

2.2 Sports of the WTG

The WTG are hosted every year, with the Winter Games taking place in those years of an even denomination, whereas the Summer Games take place on every alternating odd year (History of the Games, 2014), such as the 2013 Summer Games hosted in Durban, South Africa. At the Summer Games, athletes are able to take part in a variety of sports, including: Badminton, Cycling, Golf, Track and Field and Swimming. In addition, the host nation of the Games has the opportunity to add two additional sports, with the consent of the WTGF, which for the 2013 Games included the sports of Petanque and Ten Pin Bowling.

Even though each of these sports are hosted under the banner of the WTG, they are governed and regulated by a recognised, reputable body / federation and follow a chosen set of rules, unless these rules subject the participant to negative sequelae as a result of their transplant. These specific rules may then be altered by the WTGF to protect the participants and reduce the impact on the athlete's health (World Transplant Games Federation, 2013).

2.2.1 Sports and Events

The benefits of participating in regular physical activity are well documented (Harmon, 2009), therefore the WTG has multiple sporting disciplines to accommodate all transplant recipients (World Transplant Games Federation, 2013). Given the lack of information regarding the injuries commonly experienced by transplant athletes (Johnson *et al.,* 2013), a review of the literature pertaining to common injuries in the healthy athlete population is carried out below. Through the identification of common injury trends in "normal" athletes, this information may then be extrapolated and combined with the knowledge of known side effects of solid organ transplantation (Schonder *et al.* 2010; Unterman, *et al.* 2009; Diep *et al.* 2008) in order to possibly provide insight into expected injury trends in the transplant athlete population. The sports of the 2013 WTG will be briefly presented in this section by means of description, rules and equipment, format and discussion of the literature surrounding the injuries associated with each sporting discipline.

2.2.1.1 Badminton

Badminton is a racquet sport which is played by either two opposing players, in singles, or two opposing pairs of players, for doubles competitions. The game is played on a rectangular court, divided in two halves and separated by a net. Points are scored by striking a shuttlecock with the racquet so that it passes over the net and lands in the opponents half of the court. The shuttlecock may only be struck once by each player or team of players before it passes over the net rules (Badminton World Federation, 2014).

2.2.1.1.1 Rules and Equipment

Tournaments are governed by International Badminton Federation rules (Badminton World Federation, 2014). The court, net, feather shuttlecocks and racquets are required. Usually the former three are supplied by the WTG and the latter is based on participant preference and supplied by the participant.

2.2.1.1.2 Format

Competition is in men's and women's singles, doubles and mixed doubles, while competition in junior boy's and junior girl is in singles and open junior doubles. After preliminary round(s), there is a single elimination tournament (Badminton World Federation, 2014). Promotion within the competition is based on the best of three games to a score of 21, utilising rally scoring (Shariff, George and Ramlan, 2009).

2.2.1.1.3 Literature pertaining to Badminton

Badminton is a non-contact sport which can be played by individuals of all ages and genders at all levels, and is thus one of the most widely-played sports in the world (Shariff, George and Ramlan, 2009), with an estimated 150 million people playing the game worldwide and approximately 2000 players participating professionally in international badminton competitions annually (Jafari *et al.,* 2014). The game requires or involves a great deal of jumping, lunging and rapid changes in direction, together with often forceful and quick arm movements in a number of postural positions (Backx *et al.,* 1989).The demonstrated risk of musculoskeletal injury is approximately 1.6-2.9 injuries per 1000 hours of play (Jørgensen and Winge, 1987), which is a low proportion and supports Backx *et al,*'s (1989) assertion that badminton is considered a very safe sport. This view has, however, has been challenged more recently because an analysis of the injuries incurred at the London Summer Olympics revealed that badminton was considered one of the sports with a high risk of injury (Engebretsen *et al.,* 2013).

Several studies have discussed the epidemiology of injuries amongst badminton players and these are discussed below:

- Yung *et al.* (2007) retrospectively reviewed the injury data from 44 elite badminton players from Hong Kong in 2003. A total of 253 injuries were recorded over a one year period. Of this, 128 injuries were noted as being recurrent in nature and the remaining 125 as being new injuries. An overall incidence rate of 5.04 per 1000 playing hours was noted (which is significantly higher than Jorgensen and Winge [1987] 1.6-2.9 injuries per 1000 playing hours). This would suggest that over time there has been an increase in the number of injuries, which may be attributed to increased demands on the athlete (Hyde and Gengenbach, 2007). It was noted that elite senior athletes sustained the highest number of recurrent injuries (98 cases of 158 cases total) whilst those athletes in the junior elite and potential athlete groups sustained more new injuries (37 and 28 cases of 60 and 35 total cases respectively). Upon examination of the incidence of injury by body region, the authors noted that injuries to the back, shoulder, thigh and knee were the most commonly injured areas amongst all age groups and competitive levels. Another important finding of this study is that the injury incidences were significantly greater during competition (which concurs with the suggested increase in demands on players) than during training. This may be attributed to competition imposing additional physical and psychological stresses on athletes and may lead to the higher incidence of injury (Yung *et al.,* 2007; Robergs and Roberts, 1996).

- Similarly, Muttalib *et al.* (2009) retrospectively investigated the prevalence of injuries amongst recreational badminton players. The difference in methodology entailed the use of a descriptive interview process. Of the 86 recreational badminton players that were interviewed for this study, only 51 met the inclusion criteria. Of the 51 participants, 39.21% complained of a recent bout of pain and/or stiffness directly after having played badminton. The most commonly affected areas were: the shoulder (30%), the low back (30%) and the knee (20%); which seems to concur with Yung *et al.* (2007). In 85% of the injured players, the severity of the pain was adequate enough for them to seek treatment for their injuries. The remaining 15% of injured players simply took a decision to rest from playing badminton to alleviate their pain/allow their injury to heal without any medical attention.
- Shariff *et al.* (2009) also conducted a retrospective study, reviewing the case notes of all badminton players who attended the National Sports Institute (NSI) Clinic, Kuala Lumpur, Malaysia, and who were diagnosed with musculoskeletal injuries. The archived data was from a two and a half year period (January 2005 to June 2007), in which 469 musculoskeletal injuries were diagnosed and reported. In contrast to Muttalib *et al*. (2009) it was found that only a small number (1.7%, of the total recorded injuries) of injuries occurred during competition, with 86.6% of total injuries sustained during training or practice sessions. The remaining injuries were not accounted for. This resulted in the authors drawing the conclusion that overuse was the commonest cause of injury, accounting for 36% of all recorded injuries. The most common area of injury was the lower limb (63.1% of total number of injuries), with the knee accounting for 23.5% of total injuries and 37.1% of all lower limb injuries. The most prevalent knee injuries were patellar tendinopathy (42.7%) and muscle strains (11.8%). Whilst lower limb injuries were more common than those affecting the upper

limb (36.9%), the shoulder was recorded as being the most commonly affected area of the upper limb (36.9% of upper limb and 13.6% of total injuries), with rotator cuff tendinopathy being the most frequent complaint.

- Based on a similar methodology to Yung *et al.,* (2007) and Shariff *et al.,* (2009), Seme and Kondric (2013) carried out a retrospective analysis of sports injuries reported amongst Slovenian badminton players over the 12 months preceding their study. This data was gathered via a questionnaire issued to 26 elite Slovenian badminton players. No significant association between gender and injury occurrence was noted (possibly due to small sample size [Mouton, 1996]), however the presence of having had a previous injury was a significant risk factor for injury. The most commonly injured areas were identified as being the shoulder (30.8%) and the ankle (30.8%). In contrast to Yung *et al.* (2007), the majority of injuries were noted as being acute (14 out of 18 total cases) new injuries.

From the presented evidence it is suggested that the low back, shoulder and thighs / knees are the most commonly injured areas in the badminton player, with limited agreement on acute versus chronic injury statistics as well as risk factor identification. These latter inconsistencies may be related to the relatively small sample sizes of some studies (Yung *et al.,* 2007; Shariff *et al.,* 2009; Seme and Kondric 2013) and the predominantly retrospective nature (Yung *et al.,* 2007; Shariff *et al.,* 2009; Seme and Kondric, 2013) of the above studies that relied on the athlete's ability to recall injuries and incidences related to play or training. This latter weakness referred to as "memory decay" by Mouton (1996), could have significantly affected injury reporting and skewed data reported and could account for the differences between studies (Seme and Kondric, 2013; Muttalib *et al.,* 2009; Shariff *et al.,* 2009; Yung *et al.,* 2007). These outcomes therefore hamper the development of succinct and accurate preventative training programmes for athletes generally (Finch and Cook, 2013; Junge *et al.,* 2008) and transplant athletes specifically (Ramasamy, Hill and Clasper, 2009). Therefore it is imperative that data is generated for the transplant population through prospective and retrospective investigations (WHO, 2001).

2.2.1.2 Cycling

Cycling is defined as the sport or activity of riding a bicycle (Oxford Dictionaries, 2014). There are four main categories of cycling as recognised by the *Union Cycliste Internationale* (UCI) (UCI, 2014), namely: Road, Track, Mountain and Cyclo-cross. The format for the 2013

WTG included two separate events; the 5 km closed course time trial on the road and the 20 km road race.

2.2.1.2.1 Rules and Equipment

Both events were governed by the rules as set out by the *Union Cycliste Internationale* (UCI, 2014). The participant usually has a bicycle that is suited to their height and leg length, with specific adaptations being made for comfort and increased performance ability (Mills, 2006). The race course is usually a predefined route either within a specifically designed track or through negotiations with local authorities on roadways around the precinct of the WTG facilities (Rules for the Sports of the 2013 World Transplant Games, 2012). Helmets are to be worn by all participants and must be provided by the participant (UCI, 2014).

2.2.1.2.2 Format

The format of the (cycling) events is simple and requires a race from the start against fellow participants as well as the clock. The aim is to complete the race as quickly as possible within the parameters of the outlined race course (UCI, 2014).

2.2.1.2.3 Literature pertaining to Cycling

Cycling, whether recreational, competitive or utilised as a rehabilitative form of exercise has increased in popularity over the past decade (Buschbacher *et al.,* 2009; Mills, 2006). However, this increase in popularity has led to an increased susceptibility to injury, particularly amongst those recreational cyclists, who may present to sports medicine professionals for assessment (Buschbacher *et al.,* 2009). In South Africa there has been a growth in participation of both recreational and competitive cycling, and, subsequently, an increase in the number of patients with cycling related injuries presenting to various medical practitioners (Schwellnus, 2005). Cycling injuries, like most, are classified as either being extrinsic (traumatic in origin) or intrinsic (overuse in origin) in nature (Mills, 2006; Brown, 2002). The majority of extrinsic bicycling related injuries occur to the upper and/or lower extremities (Thompson and Rivara, 2001). Bicycling related intrinsic injuries arise as a result of either chronic overload to an anatomical structure or through injuries related to micro-traumatic events (Khan *et al.,* 2000).

- In the context of the above, Bagherien and Nader (2010) retrospectively analysed the injury data from 93 cyclists (2009-2010). In total, 117 injuries were reported, translating into 1.2 injuries per cyclist per year. The most common injuries experienced were abrasions, which accounted for 63% of all injuries, followed by contusions (23%) and strains (8%) [resulting in minor (95%) acute (94%) injuries comprising the majority of reported injuries]. It therefore follows that collision injuries were responsible for 92% of all injuries in comparison to the 8% of injuries arising as a result of non-collision or overuse aetiologies. The majority of the injuries affected the upper and lower extremities equally (48%), with the knee (18%) and the wrist/ palm and shoulder and clavicle (both 16%) being the most common anatomical sites for injury. These results agree with Thompson and Rivara (2001), who found that extrinsic injuries are usually related to injuries of the extremities. This is further supported by the findings of Bagherien and Nader (2010) whose results suggested that injuries sustained in competition were five times more frequent than during practice. This latter finding may be related to the pressures of competing against the clock (UCI, 2014) in competition as opposed to training rides.
- In the same year Clarsen *et al.* (2010) retrospectively investigated and reported the epidemiology of overuse injuries in professional road cyclists. Interviews were carried out with 109 cyclists from seven professional teams, with an emphasis on determining if the athlete had sustained an overuse injury in the preceding 12 months. A total of 94 separate injuries were recorded, with 45% being related to the low back and 23% in the knee. Of all cyclists, 58% had experienced low back pain in the previous twelve months, of whom 41% sought medical attention. A total of 36% of cyclists had experienced anterior knee pain of which 19% sought medical attention for it. The authors (Clarsen *et al.,* 2010) concluded that knee injuries were the most likely to cause time loss from cycling, whilst low back pain caused the most functional impairment. These results are in contrast to those found by Bagherien and Nader (2010), which may be due to the fact that Clarsen *et al.* (2010) utilised an interview based qualitative methodology and focussed principally on injuries that did not require reporting or that the cyclist though they could deal with (as it was perceived as a minor, non-limiting injury) as compared to Bagherien and Nader (2010) who required that the injuries be reported in a documented (surveillance) manner and thus was limited to injuries that were perceived to be significant either by the cyclist or the medical personnel available at the time (and therefore documented).
- As a result of the differences found in the above two studies, Palmer-Green *et al.* (2014) carried out a longitudinal prospective surveillance study of injuries in British

Cycling from 2011-2013. The study recorded all injury data collected at the British Cycling National training centre, domestic and international training camps and at competition venues over this period. In total 61 participants took part, all were national team athletes in at least one cycling discipline. As this was a prospective study, data regarding time loss from training and competition and performance restriction was also analysed (taking Palmer-Green *et al.*'s (2010) study one step further when compared to Clarsen *et al.,* (2010) and Bagherien and Nader (2010)). In total 95 injuries were recorded, indicating the likelihood that cyclists would sustain at least one injury in a single season (affecting 35% of the squad) (not unlike the results obtained by Bagherien and Nader, [2010]). Training injuries were found to be more prevalent and likely to be related to overuse (58%) (not unlike Clarsen *et al.,* 2010), whereas competition injuries were seen to be acute (42%) and more severe in nature and thus associated with lengthier amount of time loss (14 days versus 27 days). The most common injury sites were noted as the lumbar spine (29%), knee (18%) and shoulder/clavicle (14%). Therefore the results of Palmer-Green *et al.* (2014) were able to contextualise the relationship of the intrinsic and extrinsic injuries that were previously reported by Clarsen *et al.* (2010) and Bagherien and Nader (2010), allowing for appropriate and contextual understanding of the relationship between the two.

Therefore, from the presented evidence it seems that the low back and knees are the most commonly injured anatomical regions in the cyclist. However, the degree to which the studies (Bagherien and Nader 2010; Clarsen *et al.,* 2010; Palmer-Green *et al.,* 2014) agree varies and these inconsistencies may be related to the predominantly retrospective nature of some of the studies (Bagherien and Nader 2010; Clarsen *et al.,* 2010) that rely on the athlete's ability to recall the required information (Mouton, 1996). This may have significantly affected injury reporting (Mouton, 1996). This disagreement between the results show that further data is required, as the lack of data hampers the development of appropriate preventative training programmes for athletes (transplant and non-transplant athletes) (Finch and Cook, 2013; Junge *et al.,* 2008).

2.2.1.3 Golf

Golf is a popular sport played worldwide by people of all ages and genders (Fradkin *et al.,* 2007). The popularity of the sport is owed largely to the fact that there are no limitations to participation in terms of age, gender and / or skill level (Fradkin *et al.,* 2007; Thériault and Lachance, 1998). Golf is a sport or game played on a large open-air course, in which a small hard ball is struck with a club towards and into a series of small holes in the ground, the object being to use the fewest possible strokes to complete the course. There were two divisions in which athletes could compete at the 2013 WTG, these being the gross or scratch and the net or handicap divisions. Individual and team events were hosted in each of the divisions (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.3.1 Rules and Equipment

All golfing events are governed by the Royal and Ancient Golf Club of St. Andrews (R and A) Rules (Rules for the Sports of the 2013 World Transplant Games, 2012). These rules require that golf clubs manage their estates so that it enables play, where players provide their own clubs and balls. All games for the 2013 edition of the WTG were hosted at the Mt. Edgecombe Country Club, Course One.

2.2.1.3.2 Format

For the individual events: in the gross (scratch) division, golfers compete in an 18-hole stroke-play individual tournament by age group. In the net (handicap) division medals for the individual competition are awarded in the following handicap groups: 0-8, 9-16, and 17-25 (Rules for the Sports of the 2013 World Transplant Games, 2012).

For the team event, two players from the same country may be nominated for the team event; there is no limit on the number of teams from a country. This event is not age specific and is conducted as an open event with men’s, mixed or ladies’ combinations eligible (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.3.3 Literature pertaining to Golf

The occurrence of injuries in golf is uncommon, although McHardy *et al.* (2007) suggest that injuries incurred whilst playing golf are increasing and cause for concern. In contrast to the popularity of golf and the ever expanding market and advancement in technologies, particularly that of equipment, there is a paucity of literature pertaining to golf injuries (McHardy *et al.,* 2007). This may be because surveillance requirements for injury reporting do not exist for golf and the lack of acute injuries requiring prompt medical attention which would have had to be recorded in line with medical provision procedures (World Transplant Games Federation, 2013). This assertion is supported by Fradkin, Cameron and Gabbe (2005), who state that a lack of recognition of the injuries sustained during golf may also be related to the lack of contact injuries (e.g. rugby) and the lack of injuries resulting in morbidity or mortality of participants. Even if golf does not produce injuries requiring urgent medical attention, the reality is that overuse injuries / repetitive strain injuries may decrease the level or duration of competition of a participant; therefore there is a need for further research in this field (Fradkin, Cameron and Gabbe, 2005).

In terms of injury reporting,

- Gosheger *et al.* (2003) performed an epidemiologic study on the variety of different musculoskeletal problems faced by professional and amateur golfers. The injury data that was generated from 703 golfers was analysed over two seasons. Of the reported injuries 82.6% were as a result of overuse, while 17.4% were attributed to a single traumatic event. Professional golfers reported a higher frequency of injuries (average of 3.06 injuries per player) than their amateur counterparts (average of 2.07 injuries per year). The most frequently injured areas in professionals were the lumbar spine (21.8%), wrist (20%) and shoulder (12.7%); compared to the elbow (24.9%), shoulder (18.6%) and lumbar spine (15.2%) among the amateur golfers. The majority (51.5%) of injuries were of a repetitive nature and classified by the respondents as minor in nature, whilst 21.7% of cases were considered more serious (not necessarily more acute or traumatic), resulting in impediments to participating in golf.
- Similarly, Fradkin, Cameron and Gabbe (2005) conducted a prospective study. They distributed questionnaires to the players (n = 522) of the metropolitan and country Victorian Women's pennant competitions. A total 184 of injuries were reported over the 12 months of the study (0.3 injuries per player per year of participation). Of the golfers, 31.4% had a history of one injury, 3.6% two injuries and 0.2% three or more injuries. As with Gosheger *et al.* (2003), the low back was reported as being the most frequently injured body region (31.5%), with strains being the most frequent type of injury. The most common cause of injury was identified as being overuse (43.6%), followed by musculoskeletal sequelae of technical error (18%). Of the total 184 injuries, 154 (83.7%) were significant enough to require treatment from a health professional.
- Unlike Gosheger *et al.* (2003), Fradkin, Cameron and Gabbe (2005) and McHardy *et al.* (2007) retrospectively investigated the epidemiology of specifically golf-related low back injuries. This seems to have been based on the outcomes of the previous two

studies where both showed that the low back / lumbar regions were most frequently cited as injured anatomical regions. McHardy *et al.'*s (2007) survey was mailed to members of randomly selected golf clubs throughout Australia. A total of 1634 amateur golfers across Australia completed the survey, with 17.6% of these having sustained at least one injury in the past twelve months. Of the reported injuries, 25% were to the low back region, 15.3% to the elbow and 9.4% to the shoulder and the remaining 50.3% accounting for the cumulative variety of injuries to the foot, ankle, knee, hip, mid-back, upper back and neck. The most commonly perceived causes in the cohort were found to be related to a poor swing (46.9%) (technical error) and overuse (24.5%).

It is apparent from the currently available literature regarding golf injuries (McHardy *et al.,* 2007; Fradkin, Cameron and Gabbe 2005; Gosheger *et al.,* 2003), that the injury pattern, although seemingly consistent between the reports discussed above, seems to lack detailed discussion on incidence, prevalence and potentiating factors of injuries (Cabri *et al.,* 2009). Similar to the literature on cycling and badminton, the data for golfing injuries seems to be reliant on retrospective studies (McHardy *et al.,* 2007; Gosheger *et al.,* 2003), allowing it to fall prey to the same limitations of retrospective data collection methods, and hence also the development of appropriate treatment and management plans for players in order to treat acute injury and prevent future injury (Finch and Cook, 2013; Junge *et al.,* 2008).

2.2.1.4 Lawn bowls

This is a game played with heavy bowls, the object of which is to propel one's bowl so that it comes to rest as close as possible to a previously bowled small ball, the "jack". Bowls is played chiefly outdoors on a closely trimmed lawn called a green (World Bowls, 2014).

2.2.1.4.1 Rules and Equipment

The tournament was governed under the rules of the World Bowls Board (Rules for the Sports of the 2013 World Transplant Games, 2012). Competitors are encouraged to provide or play with their own bowls. It is compulsory for all players to wear shoes with a flat sole and adhere to the appropriate dress code (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.4.2 Format

Competitions are based on either individual participation, by age group, or as a pair (not restricted to any age group). The tournament is structured in a round robin format, with the top players and teams advancing to the knock-out stages of the competition (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.4.3 Literature pertaining to Lawn Bowls

A study conducted in 2002 by the Monash University in Australia is the most referenced work pertaining to lawn bowls injuries (McGrath and Cassel, 2002). Whilst lawn bowls is a popular sport in Australia, there is no comprehensive data regarding lawn bowls injuries (McGrath and Cassel, 2002). This lack of data may be as a result of the lower impact and physical intensity of lawn bowls, compared to other sporting codes, thereby reducing morbidity and mortality and thus interest. Another reason offered by McGrath and Cassel (2002) for this lack of data is that the majority of injuries amongst bowlers, based on anecdotal evidence and their research, are more likely to be acute minor injuries (e.g. sprains or strains). Ordinarily patients presenting with these types of injuries will seek medical care from other practitioners, such as their general practitioner or chiropractors, as opposed to presenting to a hospital emergency room (McGrath and Cassel, 2002), thereby decreasing the reporting of such injuries within the medical surveillance and reporting structures provides at sporting events (Finch and Cook, 2013) such as the WTG.

- McGrath and Cassel (2002) retrospectively reviewed injury surveillance data gathered on both the new Victorian Emergency Minimum Dataset (VEMD) and the Victorian Injury Surveillance System (VIIS). There were a total of 29 lawn bowl injury cases that were recorded (3 = male and 12 = female on the VEMD and 4 = male and 10 = female on VIIS). It was noted that 76% of injured players were female, which may be indicative of a higher risk of injury amongst women. Injuries were sustained from falls (accounting for 59%), overexertion (31%) and being struck by a bowl (7%). The most common injuries were sprains and strains (35%), fractures (35%) and cuts and bruises (23%). The most common sites of injury were the ankle and the wrist, which concurs with the types of injuries sustained. In the same publication, McGrath and Cassel (2002) found a similar pattern of injury was evident in the data obtained from the National Injury Surveillance Unit in Adelaide. There were 65 recorded cases of lawn bowls injuries during the period 1986-1997. Of these reported cases, females accounted for 71% of injured bowlers, with 65% being over the age of 60. The identified causes of injury were falls (54%), overexertion (28%) and being hit by the bowl (18%). Fractures (37%) and sprains and strains (31%) were the most common types of injuries. (McGrath and Cassel, 2002).

Based on the limited data that was recorded for bowls through the surveillance tools utilised by McGrath and Cassel (2002), it would seem that older, female participants are more likely to be injured and that these injuries are more likely to be reported. The only limitation in the study presented is that it is a retrospective report (McGrath and Cassel, 2002), and therefore suffers the limitations of reporting bias and memory decay as indicated by Mouton (1996). In addition, this study only reflects what was recorded as per the rules of the surveillance systems (e.g. only injuries of a particular severity are reported and recorded) that are / were in place at the time and therefore the possibility of injury / complaint exclusion is possible. This therefore places the development of injury management and prevention strategies on the back foot, as the data available to inform these strategies are based solely on reported surveillance outcomes of studies that have inherent limitations in reporting (Mouton, 1996). This has the potential to impact negatively on the manner in which the developed strategies actually aid or hinder athletes in their quest to perform uninjured (Finch and Cook, 2013; Junge *et al.,* 2008).

2.2.1.5 Petanque

This is a form of bowls in which the goal is to throw a boule, a hollow metal ball as close as possible to a previously thrown smaller ball, known as the “jack”. Unlike lawn bowls, petanque can be played on almost any surface, with the exception of concrete, tiles or tarred surfaces. Separate competitions were hosted for men and women, with players being able to compete individually or in doubles events (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.5.1 Rules and Equipment

The event was governed by the rules as stipulated by the International Federation of Petanque (Rules for the Sports of the 2013 World Transplant Games, 2012). Competitors are encouraged to provide their own boules.

2.2.1.5.2 Format

Competition in men's and women's singles, and men's and women's doubles (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.5.3 Literature pertaining to Petanque

As this was one of the unique features of the WTG in Durban in 2013, it was unlikely that any previous data would be available. A thorough and systematic review of the literature revealed no published data on the sport or the epidemiology of injuries related to the sport of petanque. Therefore based on the absence of literature pertaining to this athletic discipline it is not possible to develop an injury management and prevention programme, that would allow athletes to be managed appropriately in order to maintain participation without injury (Finch and Cook, 2013; Junge *et al.,* 2008).

2.2.1.6 5 KM Road Race

Running is one of the most popular forms of exercise globally, with millions of regular participants (Messier *et al.,* 2008). In the United States alone it is estimated that there are 40 million regular runners, with more than 10 million running at least 100 days in a year (Messier *et al.,* 2008). At the WTG, the event was staged over a closed road circuit of five kilometres in distance (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.6.1 Rules and Equipment

Men and women competed over the five kilometre distance. Events were men's and women's individual, which are age group specific, and men's and women's teams, which are not restricted by the age of the competitors. The time permitted for the race was stipulated as 30 minutes after the winner's completion time. Medals are awarded to the first three finishers in each group in the individual events. The team event medals were determined by adding the combined times for the first three individuals of each gender from each country. The team with the lowest combined time being awarded medals, as the winners (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.6.2 Format

The individual medallists are the first three finishers in each age group. The team medallists are determined by adding the combined times for the first three individuals of each gender from each country, with the lowest combined time the winner (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.6.3 Literature pertaining to Running

Although running is an effective way to attain many health and wellness benefits, there is an associated high risk of injury (Fields *et al.,* 2010). This is evident in the fact that yearly, nearly half of all runners report an injury (Fields *et al.,* 2010). Furthermore, it has been projected that roughly 27% to 70% of runners will sustain an injury in any given year of running (Hreljac and Ferber, 2006).

- Taunton *et al.* (2002) retrospectively analysed Allan McGavin Sports Medicine Centre data collected over a preceding two year period. In this study, 2002 patients were examined of which 46% (n = 926) were male and 54% (n = 1076) were female. The most common injury site was the knee (n = 842 or 42.1%), followed by the foot/ankle (n = 338 or 16.9%), lower leg (n = 257 or 12.8%), hip/pelvis (n = 218 or 10.9%), Achilles/calf (n = 129 or 6.4%), upper leg (n = 105 or 5.2%) and the low back (n = 69 or 3.4%). The most common injuries included patella femoral pain syndrome (n = 329), iliotibial band syndrome (n = 164), plantar fasciitis (n = 159), meniscal injuries (n = 97) and tibial stress syndrome (n = 92).
- By contrast, Hendriks and Phillips (2013) prospectively assessed 50 athletes from a local running club over a 16-week period. All injury data was recorded. The results of the study indicated that 92% of the participants had sustained an injury as a result of running in the past, with 50 new injuries experienced by 16 athletes over the course of the 16 weeks of the study, producing a prevalence rate of 32%. The most common location of the new injuries were the shin/calf region (20%), followed by the knee (18%) and low back (18%). Of the new injuries, reoccurrence during the following 16 weeks occurred in 28% of participants. The most prevalent re-occurring injury were sprains of the lumbar spine (8%). The most common specific injuries were muscle strains (44%), joint sprains (34%), ligament sprains (8%), ITB syndrome (8%) and medial tibia stress syndrome (6%). The classification of injuries in terms of their

severity was noted as follows: 36% were mild and moderate, 18% severe and 10% minor.

From the above studies (Hendriks and Phillips 2013; Taunton *et al.,* 2002) it is evident that runners have a high rate of injury. Although not life threatening, these conditions increase morbidity of the runners, decreasing their ability to participate and remain healthy. It is evident from the comparison of Taunton *et al.* (2002) with Hendriks and Phillips (2013) that retrospective data analysis tend to bias the results in favour of more severe injuries that spread the injury load per anatomical region slightly differently to prospectively collected data. With health being an important consideration in transplant recipients (Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008), it is essential that health care providers be provided with information that can assist in preventing injury and / or restoring health in order to maintain the ability for transplant participants to maintain their health. Compared to Petanque, Badminton, Cycling, Lawn Bowls and Golf outlined previously, it would seem that the data available in terms of running injuries is mostly defined by prospective studies (Hendriks and Phillips 2013; Hyde and Gengenbach, 2007), which underpins the ability of the statistics provided to accurately drive the process of injury management and prevention plans allowing for optimal care for athletes (Finch and Cook, 2013; Junge *et al.,* 2008) participating in the disciplines designated under athletics – in particular running (Hyde and Gengenbach, 2007).

2.2.1.7 Squash

As with running, squash is a rapidly growing sport, with approximately 15 million players, from 135 nations taking part worldwide (Eime, Zazryn and Finch, 2003). It is a racquet sport played between either two (singles) or four (doubles) players in which racquets are used to strike a small, soft, rubber ball against the walls of a closed court (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.7.1 Format

All games played are to nine points, with each match being played to the best of five games. Competitions were in men’s and women’s singles as well as a junior’s singles event (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.7.2 Rules and Equipment

Each competition was governed by the World Squash Federation rules (Rules for the Sports of the 2013 World Transplant Games, 2012). Court and balls are provided by the WTG. Players to provide their own rackets, safety glasses and appropriate dress code.

2.2.1.7.3 Literature pertaining to Squash

As a result of the increasing popularity of the sport, there has been a subsequent increase in the competitiveness of the sport at school, league, provincial and national levels (Meyer *et al.,* 2007). This increase in competitiveness has meant that young squash players are now competing at higher levels of play as compared to 20 years ago (Eime, Zazryn and Finch, 2003). Only a small amount of research pertaining to the investigation of musculoskeletal injuries experienced by squash players has been conducted (MacFarlane and Shanks, 1998) and this may be related to the lack of mortality or morbidity associated with injuries in the sport (Eime, Zazryn and Finch, 2003).

- MacFarlane and Shanks (1998) conducted an investigation into the prevalence of back injuries in competitive squash players (n = 1047) in the Otago region of New Zealand. This questionnaire, which reported on players past injuries, was returned by 495 participants (47.3% compliance). It was found that 52% (n = 258) of the participants indicated that they had suffered a back injury at least once in their squash playing lifetime. Of these, 33, 5% (n = 86) attribute the onset of their injury to squash, 20,6% (n = 51) had an exacerbation of a previous back injury due to squash whilst the remaining 45,9% (n = 118) felt that squash had no detrimental effect on their pre-existing back injury.
- Similarly, Meyer *et al.* (2007) retrospectively investigated the prevalence of musculoskeletal injuries in general amongst 106 adolescent (13-18 years) squash players in the Western Cape, utilising a structured questionnaire pertaining to prior musculoskeletal injury. They investigated injury prevalence, mechanism and site. The results from the collected injury data revealed that 31 of the participants (29%) had sustained a squash injury in the four weeks prior to data collection. A total of 48 injuries were reported by the group, with the most common injuries occurring in the thigh (19%), shoulder (13%) and low back (13%). No singular mechanism of injury was identified by 42% of the participants, who reported that the pain experienced was not as a result of a traumatic injury, but rather of insidious nature.

It would seem that the results obtained by Meyer *et al.* (2007) suggest that at least for low back pain the injury rate has decreased over time (33,5% to 13%) (MacFarlane and Shanks 1998), although this decrease may be attributed to population differences between the two studies. This implies that although competition and participation in squash has increased there has also been concomitant acknowledgement of low back injuries as a problem and therefore its impact may have been reduced by the application and promotion of guidelines for injury management and prevention, as suggested by Eime, Zazryn and Finch (2003). However, not possible to determine this for other squash injuries, as there is a paucity of literature with which to make similar long-term comparisons. It is therefore important for continued research (particularly prospective studies) in this domain, particularly with athletes that have greater demands placed on their physical systems, as would be the case in transplant athletes (Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008).

2.2.1.8 Swimming

Swimming is a very popular sport around the world, both as a sport and as a recreational activity (Abgarov, Fraser-Thomas and Baker, 2012). Swimming is a unique sport in the sense that it combines both upper and lower extremity strength together with cardiovascular training (Wanivenhaus *et al.,* 2012). It is estimated that, in 2012, there were roughly 23 million fitness/recreational and competitive swimmers in the United States alone (Sports, Fitness and Leisure Activities Topline Participation Report, 2013).

In essence, swimming is a sport in which an athlete attempts to propel themselves through water by using their limbs. There are four recognised strokes as stipulated by the Federation Internationale De Natition (FINA). These are: Freestyle, Backstroke, Breaststroke and Butterfly (Kammer, Young and Niedfeldt, 1999).

2.2.1.8.1 Format

At the 2013 WTG, the following swimming events were held for participating swimmers: Freestyle (50, 100, 200 and 400 meters), Backstroke (50 and 100 meters), Breaststroke (50 and 100 meters), Butterfly (50 meters), Individual medley (200 meters) and the Relay (4x50 meters and 4x50 meter medley relay).

2.2.1.8.2 Rules and Equipment

Depending on the number of participants, preliminary rounds of timed heats of each of the events are completed, with the fastest individuals from these heats progressing to the final in that event. Junior's events were specifically designated under the discretion of the WTGF (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.8.3 Literature pertaining to Swimming

In contrast to the common public perception of the swimming being a low risk activity, evidence suggests that nearly 75% of age group and developmental swimmers will experience at least one injury in their career (McMaster, 1996).

- Wolf *et al.* (2009) conducted a study in which they retrospectively investigated the injury patterns amongst Division 1 collegiate swimmers over a five season period (2002-2007). All data was extracted from the Sports Injury Monitoring System, which included all University of Iowa swimmers. A total of 94 swimmers were included in the study, including 44 men and 50 women. Within the male population there were 90 recorded swimming injuries sustained by 32 (73%) different swimmers. This resulted in an incidence of 4 injuries per 1000 exposures. In the female cohort, 35 (70%) different swimmers experienced 76 swimming related injuries, resulting in an injury incidence of 3.78 injuries per 1000 exposures. The proportion of injuries which resulted in missed time, whether competition or training was 34.4% and 39.5% in the male and female groups respectively. The most commonly injured area was the shoulder, followed by the back and neck.
- Similarly, Abgarov *et al.* (2012) investigated the trends and risk factors of swimming-related injuries in varsity swimmers during the 2007-2008 season. A total of 170 athletes from varsity teams in the Ontario University Athletics (OUA) Association took part. While 61.9% of study participants reported that they had sustained a swimming related injury prior to the start of the season, 70% of participants reported having had an injury during the season. Furthermore, it was noted that 44.1% reported that they had at least one swimming injury at the beginning of the season, 34.1% reported incurring at least one new injury during the season, 52.9% reported that they had at least one swimming related injury during the season, and 35.9% of athletes reported sustaining an injury whilst competing in the OUA Championships. A greater proportion of the total injuries incurred were of a chronic/gradual/overuse nature, with

42 out of 63 and 46 out of 72 recorded injuries within this category at the start and end of seasons respectively. The shoulder represented the most frequently injured anatomical site with 23 chronic and 10 acute cases at the start of the season, and 30 chronic and 11 acute cases at season end. Other commonly afflicted anatomical sites included the back (6 chronic and 5 acute – start of season; 3 chronic and 7 acute – end of season), knee (8 and 1; 5 and 3 respectively) and groin (3 and 1; 1 and 2 respectively).

From the data presented, it would seem that at least for swimming there is agreement in the literature (Abgarov *et al.,* 2012; Wolf *et al.,* 2009) that most athletes have a 70% chance of being injured and that the common areas seem to be the shoulder girdle complex and the back. These outcomes suggest that unlike squash, where injury in a particular area has been reduced over time, swimming injuries have not been effectively addressed through injury management and prevention programmes. This is particularly relevant as the study by Wolf *et al.* in 2009 was retrospective in nature and their results did not differ significantly from those obtained by Abgarov *et al.* (2012). Reasons for this may have been that the results in the Wolf *et al.* (2009) study were based on recorded data and may not have been able to explicitly link cause and effect However, with the input from the longitudinal study by Abgarov *et al.* (2012) it should be possible now to prepare injury management and prevention programmes.

2.2.1.9 Table tennis

This is a game based on conventional tennis, but is played indoors by two (singles) or four (doubles) players. Opponents use wooden bats to hit a small hollow ball over a table which is divided by a net (Table Tennis, 2014).

2.2.1.9.1 Format

Competitors are able to compete in singles, doubles or mixed doubles events (Rules for the Sports of the 2013 World Transplant Games, 2012). For the WTG, the juniors were limited to compete only in the singles event. The competition comprises an initial preliminary round after which a single elimination tournament is undertaken. All games are played to 11 points with a match being won on a best out of five games basis (Table Tennis, 2014).

2.2.1.9.2 Rules and Equipment

The tournament was governed by the rules as stipulated by the International Table Tennis Federation (Rules for the Sports of the 2013 World Transplant Games, 2012). Competitors provide their own paddles. The table and balls are provided by the WTG. All players are to wear court shoes and shirts which contrast with the ball (Table Tennis, 2014).

2.2.1.9.3 Literature pertaining to Table Tennis

In terms of table tennis, the following literature was available:

- A retrospective survey study by Shida *et al.* (1992) of 303 table tennis players who were selected to participate in the All-Japan Table Tennis Championship, observed the following, based on a 95.3% response rate:
  - Injuries were reported by 59.4% of the players.
  - Injuries to the waist (lumbago - 23.5%) accounted for the largest number of injuries, with knee joint injuries (13.4%) constituting the second commonest area of injury.
  - Among the diagnoses, tenosynovitis and sprains were the most frequent.
  - The majority of injuries occurred early in a player's career (first onset of injury 5.9 +- 2.4 years after commencement of participation in the sport).
  - The most prevalent cause of injury (43.9%) was as a result of either the number or the nature of the players practice sessions.

  Collectively, whilst injuries were frequent, more than 90% of players were able to return to play with no hindrance after having sought treatment.
- In a similar manner, Kondric *et al.* (2011) retrospectively investigated the epidemiology of racket sports injuries in 83 elite Slovenian players. Of the identified players, 29 played table tennis and each player was instructed to complete an injury data questionnaire. Within the table tennis player group, there were a reported total of 39 injuries. The highest number of injuries recorded in the table tennis players were that of the shoulder girdle (21.05%), with the majority of these injuries (64.1%) occurring during competition and the remaining 34.9% occurring during practice sessions.

The presented data would seem to suggest that the level of competitiveness as well as changes over time are partly responsible for the changes in the injury profiles reported by

Shida *et al.* (1992) and Kondric *et al.* (2011). However, since both these studies are retrospective in nature, they both fall prey to the limitations associated with this research design. Therefore to enable more effective change in injury management and prevention programmes, it is important to complete such studies not only in multiple groups of table tennis players but also using prospective, longitudinal study designs in order to prevent the data collection process to be affected by "memory recall" (Mouton, 1996). Additionally the effect of injury selection bias, as prevalent with surveillance systems, needs to be avoided in order to record more accurately the types of injuries to better inform injury management and prevention programmes (Finch and Cook, 2013; Junge *et al.,* 2008). This would be particularly true of transplant athletes (Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008).

2.2.1.10 Ten Pin Bowling

This is a competitive game in which a player rolls a bowling ball down a wooden or synthetic lane with the objective of knocking over as many of the ten pins ("skittles") as possible (World Bowling, 2014).

2.2.1.10.1 Format

Men and women usually compete in singles and doubles competitions as well as men's / boys and women's / girl's mixed pairs (Rules for the Sports of the 2013 World Transplant Games, 2012). For the WTG, the juniors competed separately in boy's and girl's events (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.10.2 Rules and Equipment

The tournament was governed under the rules as set out by the World Tenpin Bowling Association (Rules for the Sports of the 2013 World Transplant Games, 2012).

2.2.1.10.3 Literature pertaining to Ten Pin Bowling

Recent research estimated that 51.6 million individuals played bowls in 2007 – approximately 1 in 5 of all individuals ≥ 6 years of age (Kerr, Collins and Comstock, 2011). As a result of this high level of interest in ten pin bowling, a correspondingly large number of individuals are seemingly at risk for injury. To reduce the incidence of bowling-related injuries to the lowest possible level, the epidemiology of such injuries must be understood (Kerr, Collins and Comstock, 2011).

- Although there are number of studies which have investigated injuries amongst bowlers (Sherman, 2008; Griffith and Friscia, 2004; Ostrovskiy and Wilbourn 2004; Wysocki, 1999) these studies have investigated bowling-related injuries in either small or specialized samples and not in the general population (Kerr, Collins and Comstock, 2011). Therefore the resultant injury profiles that were created are highly group specific and therefore do not lend themselves to planning an appropriate and reasonable injury management and prevention programme.
- As a result, Kerr, Collins and Comstock (2011) examined bowling specific related injury data of persons presenting to the US Emergency Departments from 1990-2008. This retrospective study revealed a total of 8 754 bowling related injuries in the 18-year period, which correlates to an estimated 375 468 injuries nationwide, based on the statistical weighting applied to the sample injury data of the National Electronic Injury Surveillance System. Of all identified injuries, the most commonly injured sites included the finger (19%), trunk (15.8%) and foot complex (14.9%). The most common diagnoses were those of sprains and strains (42.7%) and soft tissue injury (20.3%). The most frequently injured age group was adults between the ages of 19-64, with the total number of injuries being counted at 235 885. The youth category (ages 7-18) were the next most injured group (n = 68 639), followed by seniors (ages > 65) with a total of 36 069 injuries. Although this study by Kerr, Collins and Comstock (2011) is a good basis for starting to understand the injury profile of ten pin bowlers, it falls short of being able to accurately reflect injury data, as the surveillance information utilised was limited to only those injuries that were deemed significant enough to warrant emergency room admittance. As a result, overuse, chronic and lesser acute injuries that were either not treated, treated by the player or treated by a practitioner outside of the emergency department setting were excluded. Thus the profile created by Kerr, Collins and Comstock (2011) is limited and biased based on the data tool utilised.

Thus, with a lack of complete data underpinning ten pin bowls specifically, and limited data being available for bowls generically, it is not possible to determine whether the nature of the injuries reported in these studies are similar or different. This is further complicated by the restrictions present within the data recording mechanisms in each study. In the study by Kerr, Collins and Comstock (2011), the fact that the data required all participants in the sport to report to an Emergency Department, would have limited the reported injuries to only those that the participants thought warranted admittance to an Emergency Department and would therefore have excluded any overuse injuries or injuries that were not deemed as "life-threatening" or affecting morbidity of the athlete. This requirement, although pragmatic in terms of the study injury recording mechanism, would have skewed the results in the direction of acute, traumatic injuries. It is thus not possible for health care providers to develop a holistic view of possible injuries and their mechanism thereby limiting the effectiveness or any injury prevent and management plans for athletes, their coaches or managers to implement. The impact of this on the athletes would therefore have been limited (Finch and Cook, 2013; Junge *et al.,* 2008).

2.2.1.11 Tennis

A game in which two or four players strike a ball with racquets over a net stretched over across a court. The game is played with a hollow, felt covered rubber ball on a grass, clay or artificial surface known as a court. (ITF Rules of Tennis, 2012).

2.2.1.11.1 Format

Competitions in men's and women's singles and doubles as well as mixed doubles are common. For the WTG, the juniors competed in boys' and girls' singles and open junior doubles events. After preliminary rounds a single elimination tournament is usually held, with all matches being of an eight-game pro-set format. Ties at seven games are resolved using a 12 point tie-breaker, with the first competitor to seven winning by two points (ITF Rules of Tennis, 2012).

2.2.1.11.2 Rules and Equipment

All tennis events were governed by the International Tennis Federation rules (ITF Rules of Tennis, 2012). Balls, the court and net are provided by the WTG, players are to provide their own clothing and rackets (ITF Rules of Tennis, 2012).

2.2.1.11.3 Literature pertaining to Tennis

Tennis is a very popular sport with millions of players participating worldwide (Abrams *et al.,* 2012). Currently, there are over 200 nations who have an association with the International Tennis Federation (International Tennis Federation, 2014). As a result of the popularity of tennis, it has recently been reintroduced as a full medal sport in the Summer Olympic Games. The sport of tennis places a number of specific demands on an athlete's musculoskeletal system, which often results in injury, acute or chronic (Abrams *et al.,* 2012).

- In their study, Ellenbecker *et al.* (2009) investigated the epidemiology of injuries amongst tennis players, in order to formulate a tennis-specific strength and conditioning programme. The researchers found that the lower extremity was the most frequently injured region in tennis players (39% - 65%), followed by the upper extremity (24% - 46%), and lastly the head/trunk (8% - 22%). Thus it was no surprise that the most injured anatomical sites were the ankle and thigh, with the ankle sprain and thigh muscle strain being the most prevalent specific injury. The elbow and shoulder were the two most frequently injured upper extremity sites, with lateral epicondylitis and tendinopathies being the most frequent injuries respectively.
- Abrams *et al.* (2012) completed a systematic review of the epidemiology of musculoskeletal injuries in the tennis players. Their review found that whilst injury during participation might occur anywhere in the musculoskeletal system the data showed that the majority of injuries involved the lower extremity (31% - 67%), the upper extremity (20% - 49%) and lastly, the trunk (3% - 21%). Anatomically, the most frequent sites within the lower extremity were the ankle and thigh, with ankle sprains being the most common specific injury. The elbow was the commonest site for injury in the upper limb, with lateral epicondylitis being the most prevalent. In addition, acute injuries were found to involve the lower limb, whereas chronic injuries tended to occur more frequently in the upper extremity and trunk.

Therefore, the data for tennis, much like swimming, seems to be congruent in terms of the prevalence, anatomical location, type and nature of the injuries that present, which make it easier for health care professionals to be able to plan and structure injury management and prevention plans for these athletes (Finch and Cook, 2013; Junge *et al.,* 2008). This would be particularly true of transplant athletes as the sports specific injury data is already known and agreed upon and thus the ability to manage the impact of transplant sequelae becomes clear and is more defined (Schonder *et al.,* 2010; Unterman, *et al.,* 2009).

2.2.1.12 Track and Field

Track and field, more commonly referred to as athletics, is a popular global sport (Alonso *et al.,* 2012). It Is defined as a sport performed indoors or outdoors and made up of several events such as running, pole-vaulting, shot-putting and broad-jumping (Dictionary.com, 2014).

2.2.1.12.1 Rules and Equipment

Tournaments are governed by International Amateur Athletics Federation rules (Rules for the Sports of the 2013 World Transplant Games, 2012). The equipment is usually defined per discipline or sporting code and may include relay batons and specific dress code with identifying numbers on the athlete attire.

2.2.1.12.2 Format

The Track Events include: 100m, 200m, 400m, 800m, 1500m, 5000m race-walk (3000m for women), 4x100m relay, 4x400m relay. Preliminary heats are conducted if there are more participants than can be accommodated in the event, with the eight fastest times progressing to the next round or the final. In longer events (800m or more) preliminary heats result in the 12/15 fastest progressing to the next round or to the final. (Rules for the Sports of the 2013 World Transplant Games, 2012). Junior athletes were only permitted to compete in certain events as per the rules of the WTG.

2.2.1.12.3 Literature pertaining to Track and Field Athletics

Top-level track and field athletes are at risk of suffering from injuries and illnesses (Alonso *et al.,* 2009), as well as certain risk factors associated with top-level competition. During both practice of and competition in athletic events, the body is required to absorb and distribute large amounts of energy (Tyflidis *et al.,* 2012). An adverse effect of these substantial forces placed upon the body, is the possibility of acute or overuse injury occurring (Alonso *et al.,* 2010; Junge *et al.,* 2009). The reported injury incidence during international athletics competitions is high, with 10% – 14% of athletes participating at the 2011 Daegu IAAF Championships incurring an injury (Alonso *et al.,* 2012). Naturally then, introducing injury prevention and management strategies focused on the most relevant injuries are of interest (Bahr and Krosshaug, 2005).

- Alonso *et al.* (2012) prospectively recorded injury data on all new injuries and illnesses suffered by athletes at the 2011 Daegu IAAF Championships. A total of 1 851 athletes took part in the Championships, amongst which 249 injuries were reported. This correlates to an injury incidence of 134.5 injuries per 1000 registered athletes. The majority of injuries occurred during competition (56.2%), with overuse injuries dominating in both gradual (acute on chronic) and sudden onset (22.9% and 36.5% respectively), followed by non-contact trauma (12.4%) and recurrence of a previous injury (9.2%). The lower limb was the most affected body region, with 74% of injuries occurring in this area and hamstring strains being the most frequently diagnosed injury (16%).
- Looking at a slightly younger age group, Tyflidis *et al.* (2012) investigated the epidemiology of track and field injuries in athletic schools over a one year period, from September 2009 – May 2010. Injury surveillance data was gathered from 2 045 scholars during the aforementioned time period. In total, 150 injuries were recorded, which resulted in an injury prevalence of 13.3% or injury incidence of 73.3 injuries per 1000 athletes. Of those injured, it was noted that females sustained 55% (n = 83) of injuries and males 45% (n = 67). The knee was the most frequently injured area overall, accounting for 24.6% of recorded injuries, followed by the ankle (19.3%) and hand (18.6%). Of the recorded injuries 24 (16%) were sprains and 28 (18.6%) were strains. In addition, it was noted that those scholars participating or practicing on a tartan surface were more likely to sustain an injury (69.3%).

From the above prospectively collected data it can be seen that the reported injury incidence during international athletics competitions is high, with between 7% – 14% of athletes reporting a new injury in one season. Naturally then, introducing injury prevention and management strategies focused on the most relevant injuries are of interest (Bahr and Krosshaug, 2005). Much like tennis and swimming where the injury rates, incidence and prevalence, type and location seem to concur in the literature, it is easier to structure specific injury prevention and management strategies for coaches, managers and athletes, allowing for effective injury management from the time that the athlete participates in this sporting code (Finch and Cook, 2013; Junge *et al.,* 2008; Hyde and Gengenbach, 2007). This would be an example of a sporting code where research data can effectively be utilised for the purposes of affecting athlete morbidity positively and allowing for full participation of the athlete for a longer period than may have been possible with the injury and its sequelae (Robergs and Roberts, 1996).

2.2.1.13 Volleyball

The sport of volleyball, both indoor and outdoor formats, is one of the fastest growing sports around the globe (Souza, 2000). The development of volleyball from a recreational past-time to a highly competitive and skilled sport, as suggested by Cassell (2001), has resulted in it becoming the second most popular participatory sport worldwide. As expected in a fast paced, high impact sport, injuries in volleyball players are not uncommon, with high injury prevalence linked directly to sports specific risk factors (Cassell, 2001; Hewett *et al.,* 1999; Bahr and Bahr, 1997; Powell, 1995)

2.2.1.13.1 Rules and Equipment

Tournaments are governed by Federation Internationale de Volleyball (FIVB) rules (Rules for the Sports of the 2013 World Transplant Games, 2012). National teams usually comprise a minimum of six and a maximum of 12 players at least one of whom must be a woman (as it is required that a woman is on the court at all times). Teams may choose to use a libero (see Definitions List) to replace a player in the back row. The libero is identified by a different colour shirt. During the game, up to five substitutions are allowed per game, but none after a team has scored 20 points. Countries bringing 40 or more competitors to the Games may enter two volleyball teams if they wish. In that event, the teams will be designated "One" and "Two" and will be seeded into separate groups for the first round. Should this occur, a single player may only play on one of the teams. Generally, there is a sixteen team limit for each event. (Regles Officielles Du Volleyball, 2014; Rules for the Sports of the 2013 World Transplant Games, 2012).

All equipment provided by the WTG.

2.2.1.13.2 Format

A game for two teams (usually two or more players) in which the object is to keep a large ball in motion, from side to side over a high net, by striking it with the hands before it touches the ground .The teams may contact the ball more than once before passing it over the net to the opposing team (Regles Officielles Du Volleyball, 2014).

The first round is played as a "round-robin" where each team in a group plays against all other teams in the same group. The top team(s) in each group then progresses to the knock-out stages, which use standard seeding procedures. The first round consists of games of two sets to 25 (by rally scoring), with the winning team having to win by two points or the first team to 27 points. Ties between teams are broken by considering the scores of the sets (the best ratio of points scored divided by points lost is the winner). The bracketed playoff round is usually the best two of three games, with the third game is played to 15 points if necessary. (Regles Officielles Du Volleyball, 2014).

2.2.1.13.3 Literature pertaining to Volleyball

The majority of injuries afflicting volleyball players seem to be of an overuse nature, occurring over an extended period of time. Research shows that overuse injuries make up to 50% – 80% of all incurred injuries (Aargaard and Uregenson, 1996; Watkins and Green, 1992).

- A retrospective, epidemiological study conducted by Puckree, Nathalal and Lin (2003) of injuries amongst volleyball players in KwaZulu-Natal South Africa, surveyed 150 male and female volleyball players from 18 clubs throughout KwaZulu-Natal. It was found that 73% of participants reported sustaining an injury whilst participating in volleyball, with 45% having sustained more than one injury. A total number of 279 injuries were reported. From the analysis, males (75%; n = 91) sustained injuries more frequently than females (62%; n = 18). Acute injuries accounted for 53% (n = 57) of all injuries, with overuse injuries occurring in 48% (n = 52) of the study participants. The most frequently injured anatomical areas were the ankle, knee, shoulder, hand/finger and low back.
- By contrast, Verhagen *et al.* (2004) carried out a one year prospective study on 486 volleyball players from the second and third Dutch National volleyball divisions. In the

one year period of the study, 100 injuries were reported, resulting in an overall injury incidence of 2.6 injuries/1000 hours. The specific incidence of acute injuries was reported as being 2.0/1000 hours, with ankle sprains (n = 41) accounting for the majority of acute injuries. It was significant to note that 75% of the players with an ankle sprain reported having had a previous ankle sprain. Overuse injuries were reported in 25 cases, accounting for an incidence of 0.6 injuries/1000 hours. Shoulder injuries, accounted for 32% of all overuse injuries, followed by the back (32%) and knee (20%).

- In congruence with Puckree, Nathalal and Lin (2003), Agel *et al.* (2007) reviewed 16 years of injury data from the NCAA injury surveillance database of women's volleyball in an attempt to identify potential areas for injury prevention initiatives. In this retrospective study, a total of 2 216 injuries from more than 50 000 games, as well as 4 724 injuries from more than 90 000 practices were reported. Lower limb injuries accounted for more than 55% of total injuries, in games and at practices (in congruence with Puckree, Nathalal and Lin [2003] and less so with Verhagen *et al.,* 2004). The ankle was the most frequently injured anatomical site, with ankle ligament sprains accounting for 44.1% (n = 696) and 29% (n = 955) of all game and practice injuries respectively. In games, knee internal derangements (14.1%; n = 222) shoulder muscle strains (5.2%; n = 82) and low back muscle strains (4.8%; n = 76) accounted for the majority of injuries, other than ankle ligament sprains. In practices other commonly injured areas included the upper leg muscle-tendon strains (12.3%; n = 401) low back muscle / tendon strains (7.9%; n = 258) and knee internal derangements (7.8%; n = 252).

Therefore within the volleyball discipline, much like that of the swimming, tennis and track and field sporting disciplines / codes, it is evident that the literature (Agel *et al.,* 2007; Verhagen *et al.,* 2004; Puckree, Nathalal and Lin 2003) seems to agree on the prevalence, anatomical location and type of injuries sustained. This allows for health care professionals to define specific injury management and treatment plans for volleyball participants. With this in mind, both the specific needs of the sporting discipline (Finch and Cook, 2013; Junge *et al.,* 2008; Hyde and Gengenbach, 2007) as well as the transplant athlete (Schonder *et al.,* 2010; Unterman, *et al.,* 2009) can be more easily determined and managed.

Thus, having reviewed the data specific to each of the various sporting disciplines provided at the WTG, an overview of the likelihood of injury is possible. However, different methodologies in collecting this data and the limitations associated with these methods impacts on the understanding of the injury profiles of the different disciplines. As a result it is necessary and important that research be coherent, continuous and ongoing, allowing for a comprehensive profile of injury presentation per sporting discipline as well as monitoring changes in injury profiles (viz. the effectiveness of injury management and prevention strategies within specific sports) (Finch and Cook, 2013; Junge *et al.,* 2008; Hyde and Gengenbach, 2007). Without such data it becomes impossible for the athletes to be appropriately prepared by the coaches and managers of teams (Liebenson, 2014) and it becomes impossible for the adequate provision of medical and affiliated services at sporting venues by the organisers of such events (Hyde and Gengenbach, 2007).

In the context of the WTG, it therefore becomes important and necessary to generate data that will allow for appropriate preparation prior to the WTG as well as for medical provision during the WTG. This is based on the fact that there may be changes in these injury profile data as a result of the fact that participants in the WTG may participate in up to five individual sports (Rules for the Sports of the 2013 World Transplant Games, 2012). In addition, their inherent physiological changes (due to the transplant and the need for medication to prevent unwanted sequelae) may predispose them to specific or unique injuries that may not be detected in surveying (prospectively or retrospectively) athletes that are not transplant recipients (Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008). Thus the next section looks specifically at the limited data available in the domain of the transplant athlete.

2.3 Transplant athletes and musculoskeletal injury

In agreement with the reviewed literature for each of the sporting codes, most of the published literature pertaining to transplant athletes has focused on issues of a medical nature (defined as those medical conditions that require assessment and medical intervention in order to curb mortality or to deal with the sequelae of medical intervention for the transplant received by the athlete) (Johnson *et al.,* 2013). Although this information is helpful in addressing inherent concerns of transplant recipients, it does not allow for a complete picture of injuries to be developed. As a result, limited literature exists regarding the more chronic and insidious musculoskeletal injuries that transplant athletes are prone to, but which go unreported because of athlete perception of their effect on morbidity or mortality. This lack of information limits the understanding of the benefits of injury management and prevention programmes (including preventative manual therapy, exercise and rehabilitation and treatment options [e.g. chiropractic care]) for transplant recipients, particularly those related to musculoskeletal injuries. This is of concern, as Schonder, Mazariego and Weber (2012) state that there are a number of side effects from medication taken by transplant recipients, including musculoskeletal sequelae, which may predispose athletes to musculoskeletal injury and / or exclude them from particular forms of care. This injury related research is necessary because there is evidence that transplant athletes derive benefit from regular physical activity and sports participation (Mosconi *et al.,* 2009) and this data can support them and the manual therapists such as chiropractors who treat them. Additionally, improved ability to participate in physical activity has been linked to optimal functional recovery of the transplant recipient and can assist in counteracting side effects that transplants pose for the patients (Schonder, Mazariego and Weber, 2012; Unterman, *et al.,* 2009; Diep *et al.,* 2008).

The above discussion is further compounded by the fact that whilst transplant recipients are often at risk of numerous side effects due to immunosuppressant therapy, it is not uncommon for physicians to overlook the more easily preventable adverse effects of solid organ transplantation, such as musculoskeletal complaints (Unterman, *et al.,* 2009; Diep *et al.,* 2008). As stated previously, these orthopaedic and musculoskeletal complaints can be due to one or more of the following: long periods of immobility, a decreased bone density (as a result of long term immunosuppressant use and renal insufficiency), an often long and stressful pre-transplantation period as well as a host of other known and unknown etiological causes (Lindsay, 2004; Fahrleitner *et al.,* 2002; Shane, *et al.,* 1997). However, with frequent pre- and post-transplantation examination, appropriate activity exposure and management as well as on-site examination of these athletes at the time of competitions (e.g. WTG), these complications can be identified and treated and managed accordingly, which may reduce the burden of injury (Dagenais *et al.,* 2008) and the sequelae of these injuries and / or their predisposing factors (Lindsay, 2004; Fahrleitner *et al.,* 2002; Shane, *et al.,* 1997).

2.3.1 Epidemiology of musculoskeletal injuries in transplant recipients

Solid organ transplantation is an important lifesaving procedure mainly performed in patients with end-stage organ failure such as liver cirrhosis, congestive heart failure, and end-stage renal disease (Unterman *et al.,* 2009). In this context Kjaer *et al.* reported in 1999 that there were over 35 000 transplants performed annually around the globe. They also state that the demand for knowledge regarding exercise in daily life for transplant recipients was growing at that time (Kjaer *et al.,* 1999). Whilst there are a number of studies (Diep *et al.,* 2008; Shane *et al.,* 1997; Rodino and Shane, 1997; Egan *et al.,* 1996) which highlight the various musculoskeletal complications and complaints that are often experienced by solid organ transplant recipients; there exists a paucity of both literature and knowledge pertaining to the physical management of these complaints in transplant recipients generally. Even less information on those that participate in high levels of physical activity such as those involved in participation at events such as the WTG, is available to allow for them to be appropriately managed from a musculoskeletal vantage point. Due to this limited knowledge regarding the management of musculoskeletal complaints/complications in these patients, there is a lack of understanding on how to not only prevent these complications or lessen their severity post-transplant, but also on what effects there may be on decreasing the burden of disease and promoting or increasing quality of life (Dagenais *et al.,* 2008; Finch and Mitchell, 2002). This further complicates any injury management and prevention plans that health care professionals to be able to plan and structure for these athletes (Finch and Cook, 2013; Junge *et al.,* 2008).

In order to understand the literature more fully, several studies have surveyed the musculoskeletal injuries or pain complications which can inflict all classes of transplant recipient. These studies are discussed below.

- The medical co-morbidities following renal transplantation were investigated by Hollisaaz *et al.* (2007) by means of a cross sectional study in 2006. The evaluation of 119 kidney transplant recipients for somatic co-morbidities via the Ifudu co-morbidity index revealed a total of 14 types of chronic illnesses within the cohort. Of the 119 participants, 108 (90.4%) had at least one co-morbidity, whereas no co-morbidity was reported in 11 (9.6%) of patients. Among the transplant recipients, non-ischemic heart disease including hypertension (n = 75, 63%), visual disturbances (n = 42, 35.2%), low back pain and spine and joint disorders (n = 30, 25.21%) and musculoskeletal disorders (n = 2 8, 23.5%) were the most frequently recorded co-morbidities.
- Unterman *et al.* (2008) analysed the medical records from 1 251 solid organ transplant patient (not limited to renal patients as Hollisaaz *et al.* [2007] was) visits to an emergency department over a four year period (2000-2004). A total of 593 patients who received kidney (395), liver (161) or combined renal (37) transplants during the period of the study, a resultant 1 251 emergency department visits were recorded. This equates to an average of 3.15 emergency department visits per patient, over a mean period of 30.8 months after the receipt of the transplant. The most common presenting complaints amongst these transplant recipients were those of an abdominal nature, such as nausea, vomiting, diarrhoea and/or gastrointestinal bleeding, which accounted for 31.3% of all complaints. Complaints that were listed as 'other' included those complaints of a musculoskeletal nature (16% of total complaints). Significantly though, it was noted that cardiopulmonary and

musculoskeletal pathology rates increased with time elapsed from point of transplantation. It was reported that this may be related to the medication that transplant recipients are required to take in order to stabilise their body's reaction to the transplanted organ (Unterman *et al.,* 2008).

- More recently, Movassaghi *et al.* (2012) performed a retrospective study to evaluate the frequency of musculoskeletal complications amongst 43 solid organ transplant recipients in a tertiary health care centre in Tehran, Iran (2000-2009). Data from 43 patients (21 liver transplant cases, 21 cases of heart transplant and one lung transplant case), included participants whose age ranged from 5-58 years of age (mean 40.2 ± 10.9 years). The majority of patients were male and accounted for 76.9%, 47.8% and 100% for heart, liver and lung transplants respectively. It was noted that 40% (17) of study participants had musculoskeletal complaints, where generalised joint pain (28%; n = 14), muscular weakness (4%; n = 2), fractures (4%; n = 2), joint swelling (2%; n = 1) and skeletal pain (2%; n = 1) were the most frequently cited. By comparison the medical diagnoses included mechanical arthritis (24%; n = 12), periarthritis (6%; n = 3) and myopathy (4%; n = 2) amongst the most common musculoskeletal findings in these transplant recipients.
- In a more specific study, Koeppen, Thirugnanasambanthan and Koldehoff (2014) analysed the occurrence of neuromuscular symptomatology in patients who had received hematopoietic stem cell transplants. This prospective non-interventional study on 247 patients was carried out from July 2011 to August 2013. Amongst the 247 patients, 20 (8.1%) were diagnosed with some form of neuromuscular complication at a mean onset of 12 months post-transplant. Of the 20 patients, 5 (25%) were diagnosed with a polyneuropathy, 10 (50%) were diagnosed with combined polyneuropathy and myopathy, 4 (20%) patients were diagnosed with myopathy / polymyositis and 1 (5%) patient was diagnosed with myasthenia gravis.

From the evidence presented above, it is evident that the transplant recipient has a predisposition to the development of musculoskeletal complaints / medical diagnoses, which seem to increase with an increase in relation to the time (months) post-transplant. This may or may not be directly related to the consumption and metabolism of anti-graft rejection / immunosuppressive medication, the effects of this medication on normal physiological function and / or the need for these patients to become physically active so as to derive benefit from activity and improve their quality of life (Haskell *et al.,* 2007; Pate *et al.,* 1995).

Thus, it is important to understand risk factors that are both unique to the transplant athlete as well as those factors that predispose transplant athletes to injury in sport in order to determine their relative importance and the need to manage each or both on the part of the health care professional (Cavayero and Kar, 2014).

2.4 Risk Factors

A physically active lifestyle is important for all individuals of any age (Pate *et al.,* 1995) with many well documented benefits being attributed to physical activity (Haskell *et al.,* 2007). However, there is a certain risk involved with sports participation (Bahr and Krosshaug, 2005). Sports related injuries may also be detrimental to an athlete's health (Darrow *et al.,* 2009), as the athlete constantly faces the possibility of sustaining an injury, either minor or severe, during sports participation (Bahr and Krosshaug, 2005). Furthermore, in some instances there is a risk of possibly sustaining permanent disability or termination of an athlete's career.

These risk factors and their potential outcomes are well documented by Ristolainen (2012) and Bahr and Holme (2003). However, for simplicity of understanding, risk factors are typically classified as either being internal/intrinsic (athlete related) or external/extrinsic (environmental) in nature (van Mechelen, Hlobil and Kemper, 1992). It is important to note though that these factors do not occur in isolation and may impact directly on one another (Coetzee, 2013; Mills, 2006).

From a health care management perspective, risk factors can be further divided into modifiable (strength, balance and flexibility) and non-modifiable factors (gender and age). A number of proposed models have been developed over the past few decades that have been formulated as a means of assessing sports injury surveillance and the risk factors that are analysed in this context (van Mechelen, Hlobil and Kemper, 1992). Meeuwisse (1994) developed a model to account for all the factors involved in sports injuries and as a basis for epidemiological studies. Meeuwisse (1994) explains that although an injury may occur as a result of a single inciting event, there exists the possibility that it may have occurred as a result of the complex interaction between internal and external risk factors. Meeuwisse (1994) continues to state that internal factors such as an athlete's age, gender or anthropomorphic characteristics may have an influence on the risk of sustaining injuries, thus predisposing the athlete to injury. Additionally, external factors may play a role in modifying injury risk, possibly increasing the susceptibility to injury in the athlete. It is the relationship between these internal and external risk factors that propagates the possibility of injury in an athlete.

Whilst one must consider potential causation of an injury in athletes with regard to risk factors, it is of equal importance to take note of the various measures of injury incidence when assessing risk factors in sports studies. These measures include: injury incidence, injury prevalence, injury risk (proportion of athletes injured in a given time period), injury rate (number of injuries per unit of exposure time), odds of injury (probability injury will occur divided by probability injury will not occur), injury hazard (instantaneous or mean proportion injured per unit of time) and mean number of playing exposures to injury (Hopkins *et al.,* 2007).

Thus, risk factor identification remains a vital step in the prevention of sports injuries (Finch, Valuri and Ozanne-Smith, 1999) and it is recommended that a multi-factorial and comprehensive approach should be adhered to when approaching this topic (Bahr and Krosshaug, 2005).

There are four potential domains (Table 1) in which risk factors may combine in order to cause an injury to an athlete. The purpose of studies such as this one is to highlight which factors in each of the given domains can be modified in order to reduce injury and prevent the athlete from not being able to compete.

Table 1: Classification of risk factors

		Source of injury	
		Internal	External
Factors	Modifiable	Injury risk may be ameliorated to a degree but may not be removed entirely	Injury risk may be reduced significantly
	Non-modifiable	Injury risk is not modifiable at all	Injury risk may be ameliorated to a degree but may not be removed entirely

The next section will look at each of the factors within the domains highlighted in Table 1 to allow for a clearer appreciation of the role that health care practitioners play in reducing risk of injury to athletes and in particular transplant athletes.

2.4.1 Intrinsic risk factors

2.4.1.1 Age

Age has been identified as an important risk factor in a number of musculoskeletal conditions and injuries (Frisch *et al.,* 2009; McKay *et al.,* 2001; Peterson *et al.,* 2000). The young athlete in particular is vulnerable to sustaining sports injuries as a result of their stage of physiological growth (Adirim and Cheng, 2003). The most commonly affected body areas in the adolescent population, when compared to adults, are bone tissue and muscle-tendon units (Frisch *et al.,* 2009). One would assume then, that age would be a risk factor for sports injury, particularly in the lower limb, as older athletes would typically have an increased or prolonged exposure time to activity, whereas younger athletes would have experienced less exposure within their at risk activity (Frisch *et al.,* 2009). This, however, is not the case as numerous risk factor studies have concluded contradictory results regarding age as a risk factor for injury (Murphy, Connolly and Beynnon, 2003). In their systematic review Murphy, Connolly and Beynnon (2003) found that numerous studies (Orchard 2001; Stevenson *et al.,* 2000; Ostenberg and Roos, 2000) report an increased incidence of injury with age and several studies (Soderman *et al.,* 2001; Chomiak *et al.,* 2000) found no association between age and injury as a risk factor.. Therefore it is possible to agree with Murphy, Connolly and Beynnon, (2003) who concluded that additional research focused on larger age ranges and of similar research design need to be performed before a definitive stance on age as a risk factor can be taken.

In addition, factors that may influence the outcomes related to age in the studies such as those reviewed by Murphy, Connolly and Beynnon (2003) may include maturity-associated variations of the athletes (Maffulli and Caine, 2005), the degree of muscle mass development and its impact on movement velocity and power and measures of self-control and risk perception (Frisch *et al.,* 2009). In the transplant athlete specifically the effect of medication (Prasad *et al.,* 2003), physiological effects of specific organ transplants (Dong *et al.,* 2012; Zbroch *et al.,* 2012) and the environment within which the transplant athlete may be required to function, also need to be accounted for.

2.4.1.2 Gender

As with age, there are apparent contradictions regarding the differences in both prevalence and incidence of sports injuries between the male and female populations. These differences may be accounted for by the same factors affecting age (see Section 2.4.1.1). In general however, the assumption is that sports injuries are more sports-specific than gender-specific (particularly when one considers that certain sports are more popular amongst and participated in by certain genders, such as the popularity of netball within the female athlete group [Dyer, 1982]). It can also be seen from the review of the sports (Section 2.2.1) that lawn bowls (McGrath and Cassel, 2002) and running (Hendriks and Phillips 2013; Taunton *et al.,* 2002) tend to report a higher likelihood of injury in females as compared to swimming (Wolf et al., 2009) where there seemed to be (although marginal) a higher likelihood of injury in males. Therefore information from individual sports seems to be highly dependent on the sports type, the age group surveyed and the manner in which the survey was completed (Cavayero and Kar, 2014).

This is also reflected in the injury and illness data from the 2012 London Olympic Games (multisport) which revealed that although women suffered 60% more illness / injuries than their male counterparts (Engebretsen *et al.,* 2013), the injury rates in men and women were similar as this may reflect a regression to the mean in data where there are multiple sports types and varying ages of participation (Mouton, 1996). This concurs with a previous study by Sallis *et al.* (2001). However, this is in contrast to the findings of Conn, Annest and Gilchrist (2003) and Dempsey *et al.* (2005) who surveyed a number of sports and recreation injuries which indicated that male athletes are at a greater risk of injury compared to women. These studies therefore also dispute the findings of Elias (2001) and Powell and Barber-Foss (2000) that indicated women are at greater risk of injury than men (soccer and softball respectively). However, as the contexts of these studies are all different and the manner in which data was collected was not congruent, it is possible that none of them will agree on the extent to which gender plays a role in injury development. This is complicated further by the fact that, other reasons for higher injury risk in girls / women may include greater joint laxity (Myer *et al.,* 2008), lower muscle strength (McGuine and Keene, 2006; Jones, Louw and Grimmer, 2000) and poorer proprioception and coordination (Hewett *et al.,* 2005). There is however limited data available regarding the gender differences in sports injuries (Ristolainen *et al.,* 2009) and it still remains unclear as to whether the identified gender differences are sport specific and thus related to training and competition behaviour, or if they are, in fact, related to biological gender differences.

2.4.1.3. Previous injury and inadequate rehabilitation

Once injury occurs, there is usually a compromise within the static and dynamic stabilisers of the joints. In transplant athletes an additional compromise of the structure and composition of functional physiological parameters predisposes the athlete to increased likelihood of injury (Ljungqvist *et al.,* 2008). In both instances therefore, an associated de-afferentation of the joint has been found to occur as a result of the initial injury (Murphy, Connolly and Beynnon, 2003). For example, following the disruption of the anterior cruciate ligament of the knee, there is often a resultant increase in anterior knee laxity (episodes of the knee "giving way"), with a concomitant compromise of joint control leading to a deterioration of proprioception within the knee (Beynnon *et al.,* 1999) as a result of arthrogenic muscle inhibition (Hopkins *et al.,* 2001; Hopkins and Ingersoll, 2000). Therefore there is an increased risk of sustaining future injury related to previous injury by contributing to not only muscular weakness and imbalance (Suter *et al.,* 2000; Suter *et al.,* 1999), but through the impairment of ligaments and the fear of re-injury as well (Vlaeyen and Linton, 2000). All these factors can result in the athlete, knowingly or unknowingly, engaging in altered muscle recruitment patterns and losing focus and placing themselves at risk of further injury (Murphy, Connolly and Beynnon, 2003). Strong evidence exists to support the notion that previous injury, particularly when followed by rehabilitation that is inadequate, places the athlete at increased risk of suffering a secondary injury (Seme and Kondric 2013; Alsonso *et al.*, 2012; Verhagen *et al.,* 2004; Chomiak *et al.,* 2000; MacFarlane and Shanks, 1998; Wiesler *et al.,* 1996) or re-injury of the same type and location (Seme and Kondric 2013; Alsonso *et al.,* 2012; Verhagen *et al.,* 2004; Murphy, Connolly and Beynnon, 2003; MacFarlane and Shanks, 1998).

2.4.1.4 Aerobic fitness

Breckenridge (2007) acknowledges that, overall, the current literature pertaining to aerobic fitness as a risk factor for musculoskeletal injury suggests that a decreased level of aerobic fitness is associated with an increase of musculoskeletal injuries. These findings are substantiated by those of Murphy, Connolly and Beynnon (2003), who, in their review of the literature, found that five previous studies (Knapik *et al.,* 2001; Bell *et al.,* 2000; Chomiak *et al.,* 2000; Hopper *et al.,* 1995; Jones *et al.,* 1993) found an association between aerobic fitness and musculoskeletal injury, whereas only two did not (Ostenberg and Roos, 2000; Milgrom *et al.,* 1991). This may be as a result of two conflicting mechanisms; on the one hand no activity followed by sudden participation may lead to injury, whereas moderate activity may be protective of injury and conversely excessive participation in activity may result in fatigue and an increase in injury. These different outcomes (Murphy, Connolly and Beynnon, 2003) are related to muscle readiness, muscle endurance (Robergs and Roberts, 1996), presence of a previous injury and appropriate muscular recruitment patterns (Suter *et al.,* 2000; Suter *et al.,* 1999) as well as mental status of the athlete (Vlaeyen and Linton, 2000). Although the current literature regarding aerobic fitness as a risk factor for musculoskeletal injury is inconclusive, based on the differences (methodology and classification) between the studies, there is support for investigating this relationship further, particularly in transplant athletes whose physiological status may negatively affect muscle readiness, muscle endurance (Robergs and Roberts, 1996) and appropriate muscular recruitment patterns, through changes in biochemical processes in the body (Rodino and Shane, 1998).

2.4.1.5 Musculoskeletal factors

There are a number of musculoskeletal determinants which may act as risk factors for sports injury (Murphy, Connolly and Beynnon, 2003). These factors include, but are not limited to limb dominance, joint laxity, muscle characteristics, postural stability and anatomical alignment. These may have direct links with the athletes age (Section 2.4.1.1), gender (Section 2.4.1.2) or previous injury and adequate rehabilitation (Section 2.4.1.3).

In addition there are varying degrees of clarity regarding each of the aforementioned factors principle roles in injury causation. Limb dominance, for example remains a controversial risk factor, with several studies, such as those conducted by Orchard *et al.,* (2001); Chomiak *et al.,*(2000); Baumhauer *et al.,* (1995) and Ekstrand and Gillquist (1983) all concluding that limb dominance plays an important role in sports injury. Conversely though, authors Beynnon *et al.* (2001), Seil *et al.* (1998) and Surve *et al.* (1994) found that limb dominance did not serve as a risk factor for injury. The differences between these outcomes may be related to the handedness of the sports studied; those requiring the use of the dominant hand would naturally increase the likelihood of injury as compared to those sports that do not require the dominant hand to be utilised in executing the sport. This relationship in the cited studies is not clear and therefore future studies are required to conclusively determine for or against handedness as a risk factor for injury.

With regards to both generalised and specific joint laxity, limitations in the current research methods, combined with the inherent differences between the sports studied, make the results of the literature (Soderman *et al.,* 2001, Beynnon *et al.,* 2001, Osterburg and Roos, 2000, Krivickas and Feinburg, 1996, Baumhauer *et al.,* 1995; Hopper, Hopper and Elliot, 1995) inconsistent, thereby not allowing any conclusions regarding joint laxity as a principle risk factor for sports injury to be drawn.

Anatomical alignment as a risk factor for particularly lower limb injury has received substantial interest (Nguyen and Schultz, 2009). This is perhaps as a result of the intersegmental forces that need to be absorbed during bipedal movements required in most weight bearing sports (Reid, 1992). Various factors such as pelvic obliquity, leg length discrepancies, knee alignment, and Q-angle or rear foot position have been studied as potential contributors to alignment variations in lower limb injury sufferers (Brantingham *et al.,* 2012; Brantingham *et al.,* 2009; Soderman *et al.,* 2001; Twellar *et al.,* 1997). Although there are numerous studies which do support the role of anatomical alignment as a risk factor for injury (Brantingham *et al.,* 2013; Brantingham *et al.,* 2012; Brantingham *et al.,* 2009; Beynnon *et al.,* 2001, Wen, Puffer and Schmalzried, 1998, Cowan *et al.,* 1996, Milgrom *et al.,* 1991; Shambaugh, Klein and Herbert, 1991), there is no apparent agreement in the literature regarding the definition and characterisation of abnormal alignment or the correct method to use to measure these alignment aberrations, therefore making it an important, but difficult aspect of injury management and prevention.

In a similar vein, muscle features, such as strength, imbalance (extensors versus flexors; agonists versus antagonists) and reaction time have been shown to be important for bipedal ambulation (Taimela, Kujala and Osterman, 1990), however their role as risk factors for injury are not yet clear (Murphy, Connolly and Beynnon, 2003).

Thus, in terms of musculoskeletal factors predisposing to injury, it is apparent that the literature has yet to define whether changes within the musculoskeletal system are a predisposing factor to an initial injury or sequelae of such. However, what is evident is that once changes in the physiological, biochemical and biomechanical systems are present, the likelihood for injury increases. It is therefore important that prospective longitudinal studies are completed to conclusively document this data to add it to the pool of information available to health care professionals managing athletes (Cavayero and Kar, 2014; Finch and Cook, 2013; Junge *et al.,* 2008).

2.4.1.6 Organ transplantation

Whilst the adverse side effects of organ transplantation and the immunosuppressant therapy that accompanies it are well documented (McKenzie, McKenzie and Yoshida, 2014; Movassaghi *et al.,* 2012; Schonder *et al.,* 2010; Ritz, 2002) there is little available literature discussing organ transplantation as a potential risk factor for injury in sports. Slapak (2005) identifies certain barriers or handicaps that transplant recipients have to overcome, whether competing in sports or not. These barriers are: preceding physical damage due to primary disease and/or chronic debilitation; the effects of necessary medication; the effects of the surgical procedure, the necessity in some instances of long periods of hospitalisation and the function of an organ deprived of its intrinsic nerve supply (Cavayero and Kar, 2014; Schonder *et al.,* 2012; Schonder *et al.,* 2010, Unterman, *et al.,* 2009; Diep *et al.,* 2008; Slapak, 2005).

These barriers, together with the numerous musculoskeletal side effects often experienced by transplant recipients, as described by Schonder, Mazariego and Weber (2012), Movassaghi *et al.* (2012), Unterman, *et al.* (2009), Diep, Kerr, Barton and Emre (2008) and Hollisaaz *et al.* (2007) illustrate the probable factors which may subsequently allow organ transplantation to be regarded as a risk factor.

Whilst it is difficult to definitively classify organ transplantation as a risk factor for sports injury, based on the multitude of adverse side effects thereof, it is likely that undergoing organ transplantation can act as a risk factor for sports injury (Cavayero and Kar, 2014, Schonder *et al.,* 2012; Schonder *et al.,* 2010, Unterman, *et al.,* 2009, Diep *et al.,* 2008; Slapak, 2005).

From this discussion on the intrinsic risk factors related to injury development, it can be seen that most of these factors are non-modifiable factors, with the exception of rehabilitation, fitness and some of the musculoskeletal factors. Therefore, the aim of any health care provider should be to focus on the above intrinsic risk factors in order to ensure that the risks related to these factors are minimised or removed. This should be done in conjunction with appropriate focus on extrinsic risk factors as well.

2.4.2 Extrinsic risk factors

2.4.2.1 Level of competition

The majority of researchers share a general consensus that injury incidence is greater during competition than in practice/training sessions (Murphy, Connolly and Beynnon, 2003). This is evident in the findings of research carried out by Stevenson *et al.* (2000); Messina *et al.* (1999); Seil *et al.* (1998); Mykelburst *et al.* (1998); Bahr and Bahr (1997), Stuart and Smith (1995), Prager *et al.* (1989), Nielsen and Yde (1989) and Ekstrand *et al.* (1983). The combined findings of the above mentioned studies illustrate the likely increase in injury risk during competition, when compared to practice or training sessions. A proposed causal relationship for this finding, as put forward by Murphy, Connolly and Beynnon (2003), is that athletes may be more prone to taking more risks and aggressive tactics during competition, with a resultant increase in potential for injury. The increased incidence of injuries during competition may also arise due to fatigue, as a result of athletes having to perform multiple efforts in a day and/or over consecutive days of competition (Lund and Myklebust, 2011). Nevertheless, injury during competition or training usually indicates the degree of athlete preparation prior to the event in which they are participating. This preparation is usually linked to an injury management and prevention plan, thus the conclusion that most injuries happen in competition arenas, means that the plan and its execution have failed to address the weaknesses that athlete brings to the competition (Cavayero and Kar, 2014; Finch and Cook, 2013; Junge *et al.,* 2008; Reid, 1992).

2.4.2.2 Level of skill

Skill level as a risk factor for sports injury, or the apparent link between the two, has not been investigated to the same degree as other extrinsic risk factors. Skill level as a risk factor for sustaining injury has been investigated in various sporting codes such as male football players (Peterson *et al.,* 2000), athletes (track and field) (Chomiak *et al.,* 2000), female netball players (Hopper, Hopper and Elliot, 1995), male and female basketball players (Hosea *et al.,* 2000), telemark skiers (Tuggy and Ong, 2000), youth female football players (Soligard, 2011) and high school football players (Knowles *et al.,* 2009). The results of the above listed studies vary considerably, with no clear consensus on whether the level of skill predisposes the athlete to injury. Whilst these results may have had varying conclusions, it is of importance to keep in mind that certain considerations must be taken into account when comparing research projects. For example, different sports were investigated across different populations and may therefore have had incongruent criteria for classifying and grouping skill levels. Although there has been an increase in the assessment of skill level as a risk factor for sports injury in recent years (Hyde and Gengenbach, 2007), particularly that of football (Soligard, 2011; Dvorak *et al.,* 2000), the relationship between skill level and injury in a number of sports remains equivocal.

2.4.2.3 Coaching related factors

Coaching related factors as risk factors for sports injury include a number of individual aspects. These include; player exposure to practice and play, coaching quality and warm up / stretching routines and re-integration into sport after injury.

- Player exposure could be related to skill level, in that skill players are believed to not only train more, but virtue of their increased skill be selected by the coach to play/compete more often (Liebenson, 2014). Therefore they are more likely to be exposed to competition and therefore injury (Stevenson *et al.,* 2000; Messina *et al.,* 1999).
- Coaching quality is also a possible risk factor for injury (Ekstrand *et al.,* 1983). Although research on this particular aspect of coaching and its effects is limited (Liebenson, 2014), a coaches' education and experience, as well as their cooperation with medical staff, have been noted to be of importance (Arnason *et al.,* 1996) in injury management and prevention. Coach supervision has also been shown to be essential where sports specific training takes place, particularly in the context of re-integration of players post injury (Liebenson, 2014). Sports specific training is aimed at better preparing the athlete for the varying biomechanical loads experienced during training and competition in particular types of sport. The role of sports specific coaching is also thought to act as a protective mechanism by increasing fatigue resistance and conditioning and thereby decreasing the risk of injury (Verrall, Slavotinek and Barnes, 2005). Coach supervision is also vital in the control and moderation of training intensity and training technique, which may predispose an athlete to injury if left unchecked (Verrall, Slavotinek and Barnes, 2005).
- Olsen *et al.* 2005, have shown that incorporating a structured, supervised warm up prior to sports training or competition can significantly decrease the risk of injury in athletes. The physiological benefits of warm up, such as increased blood flow and oxygen transport to muscles, enhanced cellular metabolism, decreased viscous nature of muscle tissue, increased muscular elasticity and increased speed of nerve impulses are all well documented (Green, Grenier and McGill, 2002; Stewart and Sleivert, 1998; Rosenbaum and Hennig, 1995). However, it must be noted that there are conflicting opinions on the effects of warm up and athletic/sports performance across a multitude of fields. For instance, Ribeiro *et al.* (2014), conclude that performance in resistance training exercises was not influenced by warm up, whereas Anderson *et al,* (2014) reported increased sprint running performance after a warm up protocol. The limitation of both these studies is that they focussed on the performance of the athlete after the warm up session and did not fully document any

injury statistics, thus not allowing for the evaluation of the risk of injury in relation to the warm up, but rather only the increase in performance relative to the warm up.

It is thus evident that the factors related to the skill of the athlete and the preparation of the athlete for an event, whether it be through a structured training programme, a supervised training programme, requires the integration of a number of different services, including but not limited to the coaches, the athlete and the health care team that supports the athlete. It is imperative, therefore, that an effective multi-disciplinary team support the athlete in order to ensure that the best available evidence and clinical experience can address the athletes' exact needs (Kopansky-Giles *et al.,* 2010; Boon and Kachan, 2008; Sackett *et al.,* 2000).

2.4.2.4 Environmental factors

Various environmental factors, such as weather and field conditions, can affect the likelihood of injury in athletes during training or competition (Liebenson, 2014). The relationship between field conditions, particularly those of playing surface and injury risk are well documented (Orchard, 2001 Olsen *et al.,* 2003). Shoe-surface contact (the footing or grip provided between a particular surface and a particular type of shoe) has also been identified as an important risk factor for injury in athletes. The mechanisms through which the two above mentioned field conditions (playing surface and shoe-surface contact) can act as risk factors for injury are related to increased impact forces and increased or decreased friction, respectively. In addition, hard playing surfaces are believed to increase impact forces, possibly leading to an overload of tissues (Ekstrand and Nigg, 1989) and therefore injury. Harder surfaces may also result in increased speed during the match, which may also increase injury risk (Orchard, 2001; Norton, Schwerdt and Lange, 2001). In specific sports where gliding, cutting or pivoting between the shoe and surface are required, an increased translational or rotational friction could potentially increase the biomechanical load. This resultant increase in biomechanical load could then further result in an increased risk of ligament sprains in, for example, the ankle or knee (Olsen *et al.,* 2003; Reid, 1992).

When considering the vast range of environmental conditions or circumstances in which athletes compete (e.g. heat, humidity, windy, rain, snow), it must be noted that the biophysical properties which govern heat exchange are influenced by the surrounding environmental factors, such as temperature, humidity, air motion, sky and ground radiation as well as clothing (Gagge and Gonzalez, 1996). This, coupled with an athlete's metabolic rate and the clothing worn during competition, causes significant changes in core and body temperatures (Adeogun, 2013). Particularly in hot or humid environments, elevations in body temperature elicit heat loss responses in the way of increased sweat production and increased skin blood flow (Sawka and Young, 2005; Sawka, Wenger and Pandolf, 1996). Sweat contains essential electrolytes that, if not replaced appropriately together with water, can result in the development of imbalances, leading to dehydration and / or hyponatremia. These imbalances can adversely affect an individual's athletic or exercise performance and, in certain instances, perhaps even their health (Casa, Clarkson and Roberts, 2005; Institute of Medicine, 2005). In light of this extensive knowledge pertaining to the environmental risk factors attributed to athletic and exercise participation, heat related injuries such as heat stroke, heat exhaustion, or heat cramps (King, 2004) occur more often than necessary. This is of particular interest in transplant patients who may be suffering the beginnings of the adverse effects of transplantation, such as those highlighted by Schonder *et al.* (2010), Unterman, *et al.* (2009) and Diep *et al.* (2008) (steroid-induced diabetes, peripheral neuropathy, musculoskeletal pathology, infection and an increased risk of malignancy). Therefore it is of significant importance that coaches and health care providers ensure that the correct management and treatments are received by those transplant recipients competing in major sporting events (Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008) where environmental circumstances that are not always ideal.

2.5 The role of the health care provider

From the preceding discussion in Chapter Two and the information provided in Chapter One, it can be seen that the role of the health care provider is important in identifying, managing and then preventing re-injury as well as managing the athlete to make sure that injuries are limited. In order to achieve this, health care providers not only need to understand the relationship between the intrinsic and extrinsic factors affecting athletes, but also how these may or may not be modified by their actions, the actions of athlete, the actions of medical conditions / medications that the athlete may be on as well as the actions of coaches and managers. Once this is understood, it is also critical for the health care provider to be able to ascertain which factors are most amenable to change and which are not and how these can best be manipulated to achieve the best outcome for the athlete. This may best be achieved by a combination of multi-faceted, multi-disciplinary, multi-layered approaches to treating and managing the athlete / patient (Kopansky-Giles *et al.,* 2010; Boon and Kachan, 2008; Sackett *et al.,* 2000).

One aspect of this approach to care requires that health care providers have an understanding of the literature pertaining to athletes so as to more appropriately diagnose, treat and manage injuries sporting discipline related injuries and differentiate these from complications experienced by many transplant athletes (Ramasamy, Hill and Clasper, 2009). Without reliable health and injury information health care providers are in a handicapped, disadvantaged position (WHO, 2001); unable to provide the most appropriate care at the most appropriate time. This delay in care, particularly for transplant athletes may have dire consequences (Ramasamy, Hill and Clasper, 2009). To avoid this, health care practitioners require the ability to access accurate information that will allow them to allocate resources to effectively ensure maximal impact when dealing with the prevention, treatment and rehabilitation of injuries (WHO, 2001). In addition to this, the information obtained from this study may prove to be beneficial for future event organisers and regulating bodies of transplant athletes, by allowing them to understand the injuries and illnesses with which transplant athletes are afflicted, and in so doing be appropriately prepared to offer these athletes adequate medical care (Finch and Cook, 2013; Junge *et al.,* 2008).

Protection of athletes' health by preventing injuries is an important task for health care providers that are employed and placed by international sports federations (Junge *et al*., 2008) (such as the WTGF) to look after the athletes at an event. Pluim *et al.* (2009) point to the expectations of athletes to have health care providers present at their events, the onus of which befalls the organizers of those events to arrange. Standardised injury surveillance procedures provide information on not only the important epidemiological information, but also directions for injury prevention, and the opportunity for monitoring long-term changes in the frequency and circumstances of injury (Junge *et al*., 2008).

In terms of this research project, it is pertinent to discuss the role of the chiropractor in relation to their role in the treatment and prevention of sports injuries and their scope, in order to provide contextualisation for the involvement of the DUT Chiropractic Department in the 2013 WTG.

The primary focus of sports chiropractors is to provide care in the diagnosis, conservative management, rehabilitation and conditioning as well as performance optimization of the neuro-musculoskeletal systems for athletes (Sports Chiropractic 2013; Hyde and Gengenbach, 2007; Redwood and Cleveland, 2003). Further contributions by sports chiropractors have included roles in the development of protective gear and trauma management, athletic health maintenance (Green *et al.,* 2004) as well as spinal injury prevention (Pelletier, 2006).

In the field of sports, the role of the chiropractor has seen significant growth over the past decade (Mootz and McCarthy, 1999), on national and international fronts, with sports chiropractors being involved in many world leading sports events, such as the Olympic and World Games (Sports Chiropractic, 2013). Whether working with amateur teams or as volunteers in the community, sports chiropractors have a broad diagnostic and therapeutic role (The Chiropractic Report, 2008), which is consistent with their education and general chiropractic practice (Allied Health Professions Act 63 of 1982 as amended). This role includes the assessment of injury to and function of the neuromusculoskeletal system, manual treatments, the prescription and supervision of exercises, use of physical therapy and electro-modalities, taping, the prescription of orthotics and other supports, advice on nutrition and counselling and education (Allied Health Professions Act 63 of 1982 as amended; The Chiropractic Report, 2008).

More specifically related to transplant athletes, Burra and De Bona (2006) concluded in their study that new measures need to be implemented with the goal of improving rehabilitation and physical performance, which may enable patients to resume a more fulfilling life post-transplantation. These goals are however difficult to obtain without appropriate profiles of the population under investigation (Cavayero and Kar, 2014; Dagenais *et al.,* 2008). However only a limited number of surveillance studies have been conducted and published regarding the utilisation of chiropractic care at national and international multisport events (Nook and Nook, 2010). By analysing the data obtained in this study and ones similar to it, health care professionals (e.g. chiropractors and other manual therapists) would more appropriately be able to diagnose, treat and manage those complaints experienced by transplant athletes. It is thus of benefit to understand what the effects of chiropractic care are, when utilized by sportsmen and women (Dagenais *et al.,* 2008; Woolf and Pfleger, 2003) who have been the recipients of life saving organ and/or tissue transplantation

2.6 Conclusion

From the above discussion (Section 2.4) it becomes apparent that risk factors to injury are multiple, some are independent risk factors, but the majority are co-dependent, with specific combinations of risk factors predisposing athletes to injury at a particular point in time. This makes surveys of any kind difficult, particularly those that rely either on athlete recall or on the type of data collected by a specific surveillance agency. Prospective studies more reliable and allows these studies to draw firmer conclusions. In addition, many of the current studies, particularly in the smaller sporting codes, have small sample sizes, thus not allowing for adequate statistical interrogation of the risks, their independence and / or their co-dependence, thus limiting the ability for the literature to guide coaches and health care professionals alike. Therefore it is important to consider that all currently published data can at best be utilised as a guideline, but not as a conclusive decision making tool.

The limited data that is available is for the most part drawn from research on athletes that have not had transplants. There is a paucity of literature regarding the specific risk factors that may affect transplant athletes. This research study aimed to formulate an injury profile of those patients who presented to the Chiropractic treatment facilities during the 2013 World Transplant Games hosted in Durban, South Africa. Furthermore, the formulation of this injury profile will provide valuable insight into the common injuries, mechanisms and treatment thereof, as experienced by transplant athletes. In so doing, this will allow health care providers, including chiropractors, to approach the triage and treatment of transplant athletes with greater knowledge in the future.

CHAPTER THREE: METHODOLOGY

3.1 Study design

This study was a retrospective, descriptive, cohort analysis of the data gathered from the Chiropractic World Transplant Games form (based on the CSSA questionnaire (herein referred to as the WTG Form) (Korporaal, 2002), which was administered to all athletes and non-athletes requesting chiropractic care at the CTF during the 2013 WTG, hosted in Durban, South Africa. The aforementioned questionnaire was previously validated (Korporaal, 2002).

A retrospective design was chosen based on the need to analyse existing, collated data. As such, and in addition to the fact that the WTG took place over an extended period of time, a retrospective approach was best suited.

Approval of the research was granted by the Faculty of Health Sciences Research and Ethics committee, of the Durban University of Technology (IREC reference number 027/14, Appendix C).

3.2 Participants: Background

3.2.1 Study population

The study population consisted of all those people who had access to the Chiropractic Treatment Facilities via their accreditation received from the WTG during the 2013 WTG and who completed a WTG Form recording their consultation and their consent for their data to be utilised for purposes of research. This included all athletes, members of the organising committee, all support and other medical staff, all volunteers as well as spectators. Access to the CTF's was not open to members of the general public however. Access to the CTF established at the 2013 WTG was free of charge to all individuals. All participants were able to have any general and/or specific musculoskeletal complaint assessed at these treatment facilities, and were treated and/or referred as necessary.

Each patient making use of the CTF, was requested to sign the WTG Form (Appendix A), stipulating that they agreed to have their information used in future research, for which this project was granted permission (Appendix B). This signing of the WTG Form was not mandatory and was done at the discretion of the patient. All forms not bearing this athlete permission signature were excluded from this study. It must be noted that it was not mandatory for the patient to sign the WTG Form or to give consent to have their data utilised in future studies in order to receive treatment.

3.2.2 Sample allocation

The sample allocation included all WTG Forms collected at the various Chiropractic Treatment Facilities throughout the duration of the event. All aforementioned WTG Forms had to meet all inclusion criteria to be considered eligible for consideration in this research project. All patients had to have consented to have their information used for research. Approval for use of these records was granted for this study (Appendix B).

3.3 Data collection procedure at the CTF at the WTG: Background

3.3.1 Event logistics

The CTF at the 2013 WTG were made available to any individual attending the WTG. The facilities were established at various, pre-determined locations following an agreement between the Local Organising Committee of the WTG and the DUT.

The CTFs were located at the following venues on the following days of competition – displayed in Table 2.

Table 2: CTF venues and dates during the 2013 WTG

CTF VENUE	DATES
Durban Cycling Precinct	29th July 30th July 31st July
Durban International Convention Centre (DICC).	28th July – 4th August
Elangeni Hotel	28th July – 3rd August

Table 2 continued

CTF VENUE	DATES
Galleria/Dolphin Bowl.	28th July 30th July 31st July
Kings Park Aquatics Centre	29th July 31st July 1st August
Kings Park Athletics Stadium	31st July 2nd August 3rd August
KwaZulu-Natal Badminton Hall	29th July 31st July 1st August
Marist Stella School	29th July
Moses Mabhida People's Park	28th July 29th July 30th July
Mount Edgecombe Country Club	30th July 1st August
University of KwaZulu-Natal (UKZN) Westville	28th July 29th July 30th July 2nd August 3rd August
Westridge Tennis Stadium	30th July 1st August 2nd August
Westville Country Club	29th July 30th July 31st July 1st August

Neither limitations nor prerequisites were set in place for the use of the CTF. The only requirement was that all persons seeking treatment at these facilities were required to give their informed consent to be assessed and treated based on self-referral or referral from another medical provider at the WTG / another CTF. All patients were also required to complete the patient portion of the WTG Form. At this time it was explained to the patient that the WTF form is utilised to not only record their data, but also to allow for tracking of their response to treatment should they return to the treatment facility as well as for research purposes for the DUT. All those patients who failed to sign consent for treatment, were excluded from being treated at the CTF and referred either to the emergency medical services or physiotherapeutic services at the WTG by the student and supervising clinician. A total of 21 chiropractic students from the Chiropractic Department of the DUT were involved in the operation of the CTF's throughout the duration of the WTG. The clinical training of the students is highlighted in the DUT Chiropractic Clinic Manual (Chiropractic Programme, 2015) Furthermore; all the supervising clinicians were registered and practicing chiropractors.

Upon completion of this portion of the paper work, a student took a brief case history from the patient, elaborating on the athlete supplied information when and where needed. Thereafter a standard clinical assessment, related, but not restricted to, the anatomical area/region which the patient had a complaint about, was completed. Upon completion of the clinical assessment, the student then compiled the case in order to present it to the supervising clinician for discussion. The student, together with the supervising clinician then determined the most appropriate diagnosis and related management / treatment plan.

Therefore, all diagnoses and subsequent actions pertaining to the patient, treatment or referral, would have been conducted under the express supervision of a qualified chiropractor, as is standard practice in the Durban University of Technology Chiropractic Day Clinic and required by law (Allied Health Professions Act 63 of 1982 as amended).

The above mentioned procedure was followed by the student for each consultation with athlete(s) at each of the CTF, regardless of whether or not they had been treated previously or not, or if they had received multiple treatments throughout the duration of the WTG.

All clinically recorded information was compiled in accordance with the standard recording and reporting procedures for any and all patient consultations, as would have been done in a standard clinical practice (Allied Health Professions Act 63 of 1982 as amended).

All WTG Forms were collected at the end of the day's events by Dr C Korporaal and stored at the DUT in a safe, locked office to ensure patient confidentiality.

3.4 WTG Form development

The original CSSA questionnaire was developed by Korporaal (2002) and has subsequently been used in research projects at the DUT, such as that conducted by Murgatroyd (2009). The WTG Form utilised in this research project is an adapted version of this CSSA questionnaire (event name change only).

The original questionnaire, as developed by Korporaal (2002) as follows:

- The CSSA questionnaire was developed by means of both a focus group (Morgan, 1997; Silverman, 1997) and a pilot study. This focus group which consisted of members of the hockey fraternity, health care providers, researchers and statisticians allowed for the development of face validity as well as construct validity (Bernard, 2000).
- The CSSA questionnaire then underwent a pilot study (Fink and Kosekoff, 1998), which looked at its suitability for purpose when data was being collected. This resulted in functional changes and adaptations for ease of use, without changing the face and construct validity of the CSSA questionnaire.
- Thereafter the researcher collected data from 994 participants in her study. This data was then analysed and subjected to a post study focus group, which consisted mostly of coaches, managers, players and health care providers, who then analysed the results based on the original CSSA questionnaire to determine whether the information was valid, useful and accurate and to see whether the CSSA questionnaire was able to capture the experiences of the hockey fraternity easily and simply. This validated the original construct and face validity and determined the accuracy and effectiveness of the CSSA questionnaire.
- This lead to minor adaptations to the CSSA questionnaire and its final version.

The WTG Form was developed from the CSSA questionnaire; in that only the name of the event was changed and the rider at the top of the WTG Form was added, allowing for the DUT to collect data from persons consenting to such data collection for analysis either by staff or students as approved by the DUT Institutional Research and Ethics Committee.

Questionnaires have frequently been utilised in research processes and are one of the most popular and widely used methods of data collection (Parajuli, 2004). In a retrospective cohort analysis, the questionnaires completed by the respondents constitute the data for future research (Annum, 2015).

3.5 Permission required for this study

Permission was granted by the Chairperson of the Local Organising Committee (LOC) of the WTG, to utilize all gathered information from the CTF at the WTG in this study (Appendix B). This permission was granted through the coordinator of the chiropractic contingent involved at the 2013 WTG, as this was the manner in which the WTGF requested that the submission be made.

3.6 WTG Form selection for this study

3.6.1 Sampling method

A total sample selection was utilised for all WTG Forms meeting the inclusion criteria (Esterhuizen, 2014; Mouton, 1996). As the various CTFs were open to all attendees of the WTG (i.e. athletes, spectators, support staff, volunteers and members of the LOC). All non-athlete records were included in the study, but analysed and purposely presented separately to those of the athletes in order to gain a clearer profile of athlete only injuries.

3.6.2 Sample size

A total of 409 consultations were made to the CTF over the seven day period of the WTG. This number includes both athletes and all non-athletes. Of this number, 260 (63, 59%) WTG Forms were completed and considered eligible for inclusion in this study. This number reflects the number of eligible forms as collected over the seven days of competition.

3.6.3 Inclusion and Exclusion Criteria

3.6.3.1 Inclusion criteria

In order to have been eligible for inclusion into this study, the below criteria needed to have been met by all WTG Forms as completed by the participants:

1. The patient must have agreed to have their information made available for use in research. This study required approval to access these records (Appendix B).
2. A signed WTG Form/data collection sheet (patient, student and supervising clinician).

3.6.3.2 Exclusion criteria

The exclusion criteria of the WTG Forms reviewed in this study were as follows:

1. Incomplete WTG Forms. The WTG Forms needed to have been completed to a degree which would allow for accurate documentation of the participants injury or complaint.
2. Unsigned WTG Forms. All WTG forms not bearing the signatures of the patient, supervising clinician and the student were excluded from the study.

3.7 Research procedure for this study

All records from the 2013 WTG were collated and reviewed for the purposes of meeting the inclusion criteria as set out in Section 3.4.1.

3.8 Statistical Analysis

A review of the WTG Form was undertaken, together with the statistician, to determine the manner in which to best analyse and present the captured data (Esterhuizen, 2014). Data was captured in MS Excel (2007) and converted to SPSS version 22.0 (SPSS Inc., Chicago, Illinois, USA), (Esterhuizen, 2014) for data analysis. Descriptive statistics were used to summarise categorical data by means of frequency tables and cross tabulations between variables. Continuous data were summarised using means and standard deviations, and comparisons between groups were affected with unpaired t-tests. A p value < 0.05 was considered as statistically significant.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter reports on and displays the results obtained from the data collection process of this research project as well as the discussion of the results. This form of presentation was chosen so that each object could be presented and discussed in its entirety before the next objective is presented. This allows for a development of the discussion from objective to objective which would have been more difficult to present if the results and discussion were separated. Tables and figures were used to present the data graphically, with each table being accompanied by a short description thereof. The results in this chapter are discussed in relation to each objective of this study, as discussed in Chapter One.

The data tool used in this research project was the WTG Form which was based on the CSSA Form. This form has been previously validated (Korporaal, 2002).

4.2 Objectives

1. To determine the number of consultations made by all athletes and non-athletes to the DUT Chiropractic Treatment Facilities at the 2013 WTG.

2. To develop an injury profile of the 2013 WTG in terms of: injury prevalence per sport or activity; anatomical area, treatment intervention and treatment frequency.

3. To determine the treatment profile used in the management of patients who presented to the DUT Chiropractic Treatment facilities.

4. To passively track each individual participant who presented to the DUT Chiropractic Treatment Facilities, throughout the duration of the seven (7) days of competition, by analysing their recorded clinical data from the WTG form(s).

4.3 Data

The primary data for this project was obtained by means of reviewing the completed and eligible WTG Forms from the 2013 WTG. These forms recorded a patients demographic and injury specific information in a prospective manner, which was then able to be quantified and analysed at a later date (viz. retrospectively – as was the case in this study) (Mouton, 1996).

4.4 Population

The population for this research included all those individuals who sought treatment at the CTF during the seven day period of the 2013 WTG. This included athletes and non-athletes.

4.5 Methodological flow diagram

A WTG Form was completed at each patient consultation, irrespective of whether or not participants had presented to the same or any other CTF previously. Therefore, the number of forms correlates to the number of consultations made by patients during the 2013 WTG. The flow diagram in Figure 1 graphically depicts the way in which the reviewed clinical data in this research was collected and collated

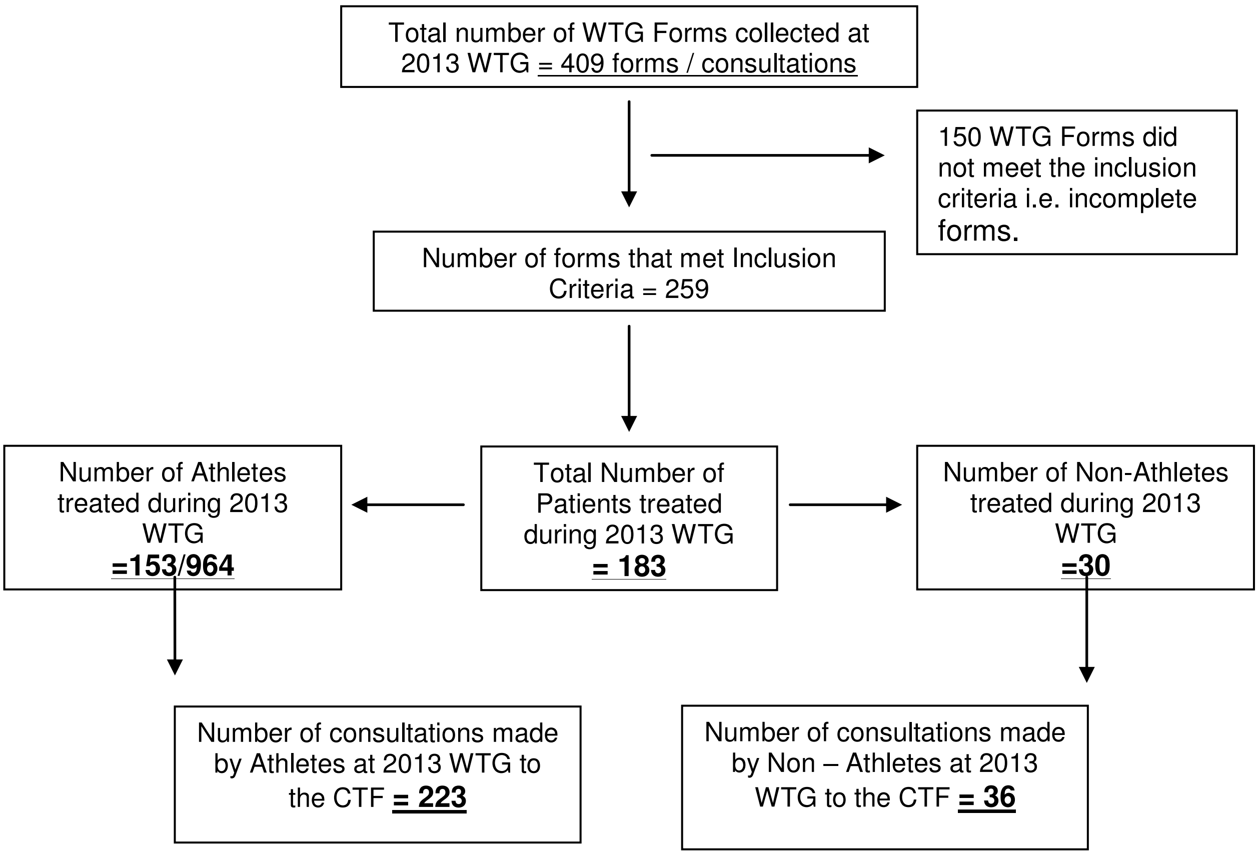

Figure 1: Methodological flow diagram illustrating the process in which data for this study was obtained and categorised

4.6.1 Objective 1: Results and Discussion

To determine the number of consultations made by all athletes and non-athletes to the DUT CTF at the 2013 WTG.

4.6.1 Number of athlete consultations per country

Chiropractic treatments were provided to all athletes and non-athletes participating at the WTG on a voluntary basis. Four hundred and nine consultations were recorded on the WTG Forms, however only 259 met the inclusion criteria as defined by this research project (See Section 3.6.3.1). There were a total of 223 treatments to 153 athletes and 36 treatments to 30 non-athletes who presented to various CTF over the seven day period of the WTG. Table 3 demonstrates the number of athletes treated per country (per total number of athletes attending the WTG from that particular country) and the total number of athletes participating in the WTG (n = 964). The response rate (Junge *et al.,* 2008), which is the number of athletes presenting to the CTF from each individual country divided by the total number of athletes participating at the WTG from that country, is depicted in Table 3.

Table 3: Number of patients presenting to the Chiropractic Treatment Facilities by Country

Country	No. Of athletes attending	No. Of athletes presenting to CTF	% Response rate: athletes consultations / athletes attending the WTG)	Total Number of consultations	% Utilisation: Number of Consultations / Total Consultations (223)
Argentina	54	2	3.7%	2	0.9%
Australia	36	8	22.2%	17	7.6%
Austria	9	1	11.1%	1	0.5%
Belgium	4	0	0.0%	0	0.0%
Brazil	4	0	0.0%	0	0.0%
Bulgaria	4	0	0.0%	0	0.0%
Canada	36	8	22.2%	20	8.9%
China	19	2	10.5%	2	0.9%
Croatia	3	1	33.3%	1	0.5%
Cyprus	5	0	0.0%	0	0.0%
Czech Republic	10	0	0.0%	0	0.0%
Ethiopia	1	0	0.0%	0	0.0%
Finland	17	1	5.9%	1	0.5%
France	53	6	11.3%	7	3.1%
Germany	27	5	18.5%	7	3.1%
Great Britain & Northern Ireland	134	17	6.6%	21	9.4%
Greece	15	2	13.3%	2	0.9%
Hong Kong	20	0	0.0%	0	0.0%

Table 3: continued

Country	No. Of athletes attending	No. Of athletes presenting to CTF	% Response rate : athletes consultations / athletes attending the WTG)	Total Number of consultations	% Utilisation: Number of Consultations / Total Consultations (223)
Hungary	48	4	8.3%	4	1.8%
Iceland	3	1	33.3%	1	0.5%
India	4	1	25.0%	1	0.5%
Iran	34	11	32.4%	12	5.4%
Ireland	23	2	8.7%	5	2.2%
Italy	22	3	13.6%	3	1.4%
Kenya	1	0	0.0%	0	0.0%
Korea	2	0	0.0%	0	0.0%
Malaysia	4	1	25.0%	2	0.9%
Mexico	1	0	0.0%	0	0.0%
Nepal	1	0	0.0%	0	0.0%
Netherlands	53	6	11.3%	7	3.1%
New Zealand	10	0	0.0%	0	0.0%
Norway	12	6	50.0%	9	4.0%
Poland	10	1	10.0%	1	0.5%
Portugal	1	0	0.0%	0	0.0%
Romania	3	0	0.0%	0	0.0%
Singapore	13	7	53.9%	12	5.4%
Slovakia	1	0	0.0%	0	0.0%
South Africa	81	8	9.9%	8	3.6%
Spain	14	4	28.6%	6	2.7%
Sudan	2	0	0.0%	0	0.0%
Sweden	16	5	31.3%	12	5.5%
Switzerland	13	4	30.8%	9	4.0%
Thailand	53	7	13.2%	9	4.0%
Tunisia	7	3	42.9%	6	2.7%
UAE [1]	1	0	0.0%	0	0.0%
Uruguay	3	0	0.0%	0	0.0%
USA[2]	67	11	16.4%	15	6.7%
Venezuela	0	0	0.0%	0	0.0%
Unknown		15		20	
Total	**964**	**153**		**223**	**100%**
Average			**15.9%**		

[1] United Arab Emirates
[2] United States of America

As shown in Table 3, the average response rate of the CTF at the 2013 WTG was 15.9%, with consultations provided to athletes from 29 (59.2%) of the 49 participating countries. This relatively high average of response rate however needs to be considered with caution, as there were some countries that had few athletes participating, which resulted in a high response rate reflected for that country (e.g. Croatia, Iceland, India and Tunisia). This high response rate per country would then have inflated the raw response rate score which was generated from an average of all countries response rates. Therefore a more realistic figure that may contextualise the usage per country would be to assess the utilisation (percentage consultations per country out of the total number of consultations that were seen). When reviewing this, the range from 0.0% to 9.4% reflects the utilisation of the CTF per country more accurately.

The countries with the highest response rates / utilisation rates at the 2013 WTG with more than 10 accredited athletes participating in the Games were: Singapore (53.9% / 5.4%), Norway (50% / 4.0%), Iran (32.3% / 5.4%), Sweden (31.3% / 5.4%) and Switzerland (30.8% / 4.0%). This contrasts with the utilisation rates (percentage of total consultations by individual country), which shows that the highest proportions of chiropractic consultations per country were: Great Britain and Northern Ireland (9.4%), Canada (8.9%), Australia (7.6%), the United States of America (6.7%), Iran (5.4%), Singapore (5.4%) and Sweden (5.38%).

The probable reasons for the differences in the response rates per country as opposed to the utilisation rates per country were most likely due to presence of a medical team with that country (most of the countries with under 40 athletes did not have a medical team with them from their country of origin) (Nook and Nook, 2009) and the ratio of team medical personnel to players (in those countries have greater than 100 athletes participating). Those countries with high ratios of athletes to team medical personnel (e.g. Great Britain) and those without team medical personnel (e.g. Iran) were more likely to utilise chiropractic services through the CTF. This concept is substantiated by Nook and Nook (2011) who noted that the chiropractic utilisation rate at the sixth All Africa Games (AAG) in 1997 was 33% higher when compared to the results from the 2009 WG. The authors attribute this difference to the likelihood that the participating African teams did not have access to their own personal medical teams and were thus more likely to utilise the local clinics and FICS clinics. This contrasts with the WG, where many sports team did, in fact, bring their own medical professional teams with them as part of their athletic care group (Nook and Nook, 2011). By contrast one would also have to consider the ability of these personal medical teams to attend to the needs of each and every athlete in their respective team on each day of the competition and at each of the competition sites. This is particularly true at a multi-sports event (e.g. the WTG, WG, AAG or Olympic Games), where sports are often hosted at a multitude of different arenas and locations on the same day (WTG, 2013). This problem would tend to affect the larger contingents of participating athletes, such as Great Britain and Northern Ireland, South Africa and the USA, where the medical personnel may be insufficient in number to be able to provide care at all venues and for all events simultaneously.

It is also however likely that the utilisation rate was influenced by the athletes prior knowledge of chiropractic services (viz. chiropractic is a known discipline in Great Britain, Canada, Australia and the United States of America) (WFC, 2014; Chapman-Smith, 2000). The apparent trend of chiropractic utilisation amongst certain countries at major sporting events may be attributed to the historic presence of and accessibility to chiropractic treatment in those countries (WFC, 2014; Chapman-Smith, 2000). The results seem to suggest that the knowledge of chiropractic (Langworthy and Smink, 2000) and the benefits of chiropractic treatment (Redwood and Cleveland, 2003) may also be better known in those countries where chiropractic is better established (Murphy *et al.,* 2008; Nelson *et al.,* 2005). Therefore although it would be tempting to assume that the utilisation is directly related to the athletes knowledge and understanding of chiropractic, it needs to be pragmatically considered that this may not have been the principle reason for this outcome and that it may have been directly related the need for medical / chiropractic assistance due to the lack of team medical provision during the time of the games. It is therefore suggested that future research attempt to correlate the total number of athletes to the number of simultaneous events and the ability therefore of their medical staffing (if present) to provide on-site care for their team's athletes and how these factors therefore affect the utilisation of medical and / or chiropractic care that is provided at the various venues during the WTG or other games.

Notwithstanding these considerations, the results in Table 3 are similar to those found in a study by Nook and Nook (2011) who found that at the 2009 WG, Canada (8.65%), the USA (6.41%), Great Britain (6.08%) and Australia (4.62%) were four of the top five countries with the highest proportion of chiropractic treatments.

4.6.2 Age, race and gender

As the demographic data obtained and analysed in this study focussed on transplant athletes, it is possible that the results of this study may be different to the published literature which has dealt principally with the normal athlete population. The principle reason for this is that transplant athletes do not necessarily reflect the demographics of the general athlete population (Movassaghi *et al.,* 2012).

Therefore, Table 4 shows the demographic data pertaining to both athletes (transplant recipients) and non-athletes (non-transplant recipients) who presented to the CTF at the 2013 WTG. Table 4 also shows the mean ages of the athletes and non-athletes groups, and the t-test to compare the two means. There was a non-significant difference between the groups ($p = 0.498$).

Table 4: Age group statistics and t-test outcomes

	Valid Number	Mean	Std. Deviation	Std. Error Mean	T statistic (*p* value)
Athlete	141	44.9	14.7	1.2	0.679 (0.498)
Non-athlete	29	42.9	13.2	2.4	

Table 5 depicts the demographic data of the athletes and non-athletes whose data was reviewed in this study. The demographic parameters include: age, gender and race.

Table 5: Athlete and Non-athlete demographic data

Demographic		**Athletes**		**Non – Athletes**	
		Count		**Count**	
Age (Years)	Minimum	11		15	
	Maximum	81		72	
	Average	44.9		42.9	
	Median	45		43	
	Std Deviation [1]	14.7		13.2	
	Valid Number	141		29	
Gender		Count	Percent	Count	Percent
	Male	109	71.24%	10	33.33%
	Female	44	28.76%	20	66.67%
	Total	153	100%	30	100%
Race	White	91	59.48%	14	46.67%
	African	7	4.58%	3	1.96%
	Indian	3	1.96%	8	26.67%
	Coloured	1	0.65%	0	0%
	Other	30	19.61%	1	3.33%
	Unknown	21	13.73%	4	13.33%
	Total	153	100%	30	100%

[1] Standard Deviation

The average age of an athlete seeking treatment at the CTF over the duration of the 2013 WTG was 44.9 years of age. The youngest and eldest competing athletes who presented to the CTF were 11 and 81 years old, respectively.

Of the 972 athletes who attended the 2013 WTG, the age groups that were most represented are depicted in Table 6.

Table 6: Distribution by age category of all registered athletes at the 2013 WTG

Ages	Athletes	Ages	Athletes	Ages	Athletes	Ages	Athletes	Ages	Athletes
6-8	1	**12-14**	25	**18-29**	150	**40-49**	205	**60-69**	130

9-11	14	**15-17**	29	**30-39**	164	**50-59**	230	**70+**	24

The only data available with regards to transplant athletes was the study by Movassaghi *et al.* (2012), who included participants in their study with an age ranged from 5-58 years of age (mean 40.2 ± 10.9 years). This compares favourably with the data of this study as seen in Table 4 and Table 5, where the mean age of the transplant athletes was found to be 44.9 years (with a SD of 14.7 years and a range of 11-81 years).

This data differs to that obtained by Junge *et al.* (2009), who found that the age of injured athletes (non-transplant) at the 2008 Olympic Games (OG) ranged from 15-53 years of age (mean – 25.7; Standard Deviation – 4.75). This data is similar to the characteristics of all registered athletes (Mean – 25.9; SD – 5.48) at the Games (Junge *et al.,* 2009). These collective characteristics may also have been influenced by limitations to participation in competition, in terms of age, in either the OG or the WTG. Although there is no age limit for competitors for the OG (other than those as prescribed in the competition rules of an international federation as approved by the International Olympic Committee (IOC) Executive Board) (Olympic Charter, 2013), limitations are in place for those transplant athletes wanting to compete in the WTG. These limitations can be found in Paragraph 3 under Section 2.1.1.

Another factor that may also have influenced the older age presentation in this study may have been linked to significant negative health care events (as found in transplant athletes) and the need for the patient to seek alternative care models to aid them in recovery or maintaining health, which would influence the transplant athlete to seek and utilise chiropractic and other Complementary and Alternative Medicines (CAM) (Tatalias, 2006). Of the non-athlete age range, the larger female representation (Whedon *et al.,* 2012; Ailliet, Rubinstein and de Vet, 2010; Humphreys *et al.,* 2010; Hartvigsen *et al.,* 2002) may have been a factor in determining the higher utilisation of chiropractic care (Tatalias, 2006; Härtela and Volgera, 2004; MacLennan and Wilson, 1996). These assertions have been found on the international stage, where the age group most likely to seek chiropractic care is that of individuals aged 30-55 years (Hawk, Ndetan and Evans, 2012; Humphreys *et al.,* 2009) and these results are similar to those as described by Brown *et al.* (2014) who describe the typical Australian chiropractic patient to be, amongst other characteristics, female and aged between 45 and 64 years of age.

In addition, although Murphy, Connolly and Beynnon, (2003) found no correlation between age and increased injury prevalence (Murphy, Connolly and Beynnon, 2003), this conflicts with Matheson *et al.*'s (1989) review of data collected over a five year period at an outpatient sports medicine clinic. The study by Matheson *et al.* (1989) compared the clinical presentation of overuse injuries, particularly, in older and younger athletes. The results showed that injuries occurred more commonly in the younger group (mean age = 30.4; SD – 8.1 yr) during running, fitness classes and field sports (Matheson *et al.,* 1989). Regarding certain specific diagnoses, tendinitis was similar between both age groups, whereas plantar fasciitis and meniscal injuries were more common in the older age group and patellofemoral pain syndrome and stress fractures/periostitis the younger age group. Regarding specific anatomical locations, the foot was more frequent affected in the older group, whereas the younger group was more likely to experience an injury in the knee (Matheson *et al.,* 1989). Thus it is also possible that different ages may present as a result of a particular type of pathologylinked to a particular sports participation and / or the age of the athlete.

Irrespective of the reasons for these results, they would suggest that the transplant population is on average approximately 15 years older than the average non-transplant athlete. This would therefore suggest that the transplant athlete is more likely to suffer from injury when one considers that literature suggests that increasing age is a predisposing risk factor for injury (Frisch *et al.,* 2009; McKay *et al.,* 2001; Orchard 2001; Peterson *et al.,* 2000; Stevenson *et al.,* 2000; Ostenberg and Roos, 2000). This may be particularly true in that the transplant athlete has specific physiological disadvantages that may further predispose them to injury (Cavayero and Kar, 2014; Schonder *et al.,* 2012; Zbroch *et al.,* 2012; Dong *et al.,* 2012; Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008; Slapak, 2005).

With regard to gender, the above discussion would also support the information on gender presented in Table 5. The data suggests that the majority of athletes who presented to the CTF were male, accounting for 71.24% of the athlete cohort. The reverse is true for the non-athlete group, in which females accounted for 66.67%.

The non-athlete group in this study concurs with the results by Nook and Nook (2011) who found that of the 1 250 female and 1 692 male accredited athletes at the 2009 World Games, 200 (16%) female and 245 (14.78%) male athletes respectively sought chiropractic care on at least one occasion. This supports the assertion that older females are more likely to know about and seek Complementary and Alternative Medicines (CAM) (Whedon *et al.,* 2012; Ailliet, Rubinstein and de Vet, 2010; Humphreys *et al.,* 2010; Tatalias, 2006; Härtela and Volgera, 2004, Hartvigsen *et al.,* 2002; MacLennan and Wilson, 1996).

However the athlete results in this study differ from the above, where the athlete group consisted predominantly of male athletes. This would agree with the findings of Junge *et al.*'s (2009) study. Although their study entailed a younger population, it found that injuries to male athletes accounted for 549 (54.2%) cases with the remaining 464 (45.8%) of injuries affecting female athletes during the 2008 OG (this was excluding the 42 cases where gender was not recorded). These characteristics were similar to the gender distribution of all registered athletes (male - 57.6% and female - 42.4%) (Junge *et al.,* 2009), which seems to have been the case in the WTG as well (however with no published data on the gender of the athletes, this assumption can only be based on the relatively higher numbers of athletes and non-athletes that sought treatment at the CTFs and the research of Movassaghi *et al.,* [2012], which indicated that the majority of transplant patients are male).

Thus, based on the work of Engebretsen *et al.* (2013) who reported that the injury rates amongst male and female athletes at the 2012 Summer OG were 121.0 and 132.8 injuries per 1 000 athletes respectively; it is anticipated that the results of this study will show that female athletes participating in the WTG would be more likely to risk injury than their male counterparts.

Then in terms of ethnicity (Table 5), this study found that the majority of participants from both the athlete and non-athlete groups were White, representing 59.48% and 46.67% of each group respectively. The next most frequently represented ethnic group in the athlete population is that of "Other" – which may indicate that the WTG Form did not allow for adequate specificity in terms of ethnicity (or the athlete was unfamiliar with their categorisation). In the context of this study however, the possibility also exists that, due to the multicultural nature of the WTG, language barriers between the chiropractic students and the athletes presenting to the CTF may have resulted in the inability to record certain demographic or clinical data correctly, such as ethnicity (Scollen and Scollen, 1995).

This outcome in the ethnicity profile for athletes and non-athletes at the WTG agrees with the research of Dagenais and Haldeman, (2012); Hestbeck *et al.* (2003); Hurwitz and Morgenstern, (1997) and Deyo and Tsui-Wu (1987), who reported on the general population presenting to chiropractic offices for a variety of complaints. In addition comparison with similar sports specific studies such as Junge *et al.* (2009), Nook and Nook (2011) and Engebretsen *et al.* (2013) is not possible because they did not record or failed to comment on the ethnic characteristics of the participants included in their studies.

For the demographic data generally, it should be considered that there may be variation of findings of risk of injury based on the age, gender and / or ethnicity of participants as these may result from preferences for certain sports (Cavayero and Kar, 2014; Hendriks and Phillips 2013; Wolf *et al.*, 2009, Taunton *et al.,* 2002; McGrath and Cassel, 2002) as well as a predilection for injury at major, multi-sports sporting events, such as the OG, WG and WTG which vary according to sporting code and sport type (Micheli *et al.,* 2001).

4.6.3. Organ transplanted

Table 7 depicts the number of athletes per organ transplanted who presented to the CTF during the WTG.

Table 7: Frequency of organ transplants by athletes competing in the WTG

Organ Transplanted	Count	% of total (n = 153)
Kidney	58	37.3%
Heart	22	14.4%
Liver	15	9.8%
Lung	12	7.8%
Bone Marrow	6	3.9%
Stem Cell	1	0.7%
Kidney + Pancreas	1	0.7%
Heart + Lung(s)	1	0.7%
Unknown	37	24.8%
Total	153	100%

From Table 7 it is apparent that more than a third (37.3%) of the patients presenting to the CTF had undergone a kidney(s) transplant. Heart (14.4%) and Liver (9.8%) were the next two most commonly received transplant organs amongst the athletes participating in the 2013 WTG who sought treatment at the CTF.

Although a large percentage of the population (24.8%) did not have their data recorded, for whatever reason (possibly language barriers), the above obtained results are within global norms. According to the 2012 Activity Report produced by the Global Observatory on Donation and Transplantation (GODT) which investigated the Organ Donation and Transplantation Activities 2012, there were approximately 11 4690 solid organ transplantations carried out globally in 2012. Kidney transplants were the most common solid organ transplanted, accounting for 67.9% (n = 7 7818) of all solid organ transplants performed in 2012. Liver transplants accounted for 20.9% (n = 23986) and heart transplants (5.2%; n = 5 935) were the next most commonly transplanted organs in 2012.

In addition, the results of this study are similar to those obtained by Johnson *et al.* (2013), who reviewed 253 questionnaires from English-speaking participants at the 2011 WTG in Gothenburg. The questionnaires were aimed at identifying the transplant recipients' experience at the 2011 WTG. From the reviewed questionnaires, it was found that the most commonly transplanted organs were kidneys (50%), followed by the liver (22%) and heart (12%) (Johnson *et al.,* 2013). The results also concur with the study of Unterman *et al.* (2008) who found that patients in their study had most often received kidney, liver or combined renal / liver transplants. It however is slightly dissimilar to Movassaghi *et al.* (2012), who reported 21 liver transplant cases, 21 cases of heart transplant and one lung transplant case in their study (this presentation may have been limited by the possibility for transplants at the centre). Nevertheless it seems that the trends in the literature seem to agree with the outcomes of this study and it is possible to state that the athletes in this study seem to represent the transplant athlete population.

Thus in summary and based on the results obtained from the transplant athletes in terms of their demographics (objective one): the transplant athletes were predominantly older (Table 5; Table 6), white males (Table 5); who had previously had a kidney transplant (Table 7) and thus it was expected that they would be predisposed to a higher injury rate than non-transplant athletes, particularly with view to the conditions in which the WTG 2013 took place (e.g. high humidity in a subtropical location). However in order to validate this assertion, the following section outlines the injury profile for the WTG athletes (Section 4.7).

4.7 Objective 2: Results and discussion

To provide an injury profile of the 2013 WTG in terms of: injury prevalence per sport or activity; anatomical area, treatment intervention and treatment frequency.

4.7.1 Injury prevalence per sport

Injury prevalence by sport: There were 223 consultations among the 153 athletes who presented to the CTF throughout the seven days of competition.

Table 8 shows that track athletics reported the most injuries (n = 76; 34%) followed by those athletes competing in multiple sports (n = 43; 19.3%) and then badminton (n = 19; 8.5%).

Table 8: Injury prevalence per sport at the 2013 WTG

Sport	Frequency	Percent	Cumulative Percent
Athletics – Track	77	34.5	34.5
Multiple Sports	43	19.3	53.4
Badminton	19	8.5	61.9
Cycling	17	7.6	69.5
Swimming	13	5.8	75.3
Lawn Bowls	12	5.4	80.7
Athletics – Field	9	4.0	84.8
Volleyball	8	3.6	88.3
Sport Unknown	7	3.1	91.5
Squash	7	3.1	94.6
Petanque	6	2.7	97.3
Tennis	3	1.3	98.7
Ten Pin Bowling	1	0.4	99.6
Golf	1	0.4	100.0
Total	223	100.0	

The reported injury rate per sport obtained in this study are not dissimilar to those obtained by Engebretsen *et al.* (2013) who ranked taekwondo (39.1%), football (35.2%), BMX (31.3%), handball (21.8%), mountain bike (21.1%), hockey (17.0%) and weightlifting (17.5%) as the sports with the highest injury rates. Similar results were obtained by Junge *et al.* (2009) who found the sports with the highest injury rates at the 2008 Summer OG were: soccer, field hockey, taekwondo, handball, weightlifting and boxing. This was followed by athletics (17.7%) and badminton (15.9%), which were included amongst the top nine sports with the highest injury rates at the 2012 Summer OG (Engebretsen *et al.,* 2013). This therefore concurs with the results obtained in this study when one excludes such sports as weightlifting, taekwondo, football and hockey from the Engebretsen *et al.* (2013) study as these were not included in the WTG (WTG, 2013). It would therefore be expected that the results from this study would be similar to the WG as these include non-Olympic disciplines, however the results where markedly different to those obtained at the 2009 WG, hosted in Kaohsiung, Taiwan (Nook and Nook, 2011). The disparity may be attributed to the sports that were participated in at the WTG (Rules for the Sports of the 2013 World Transplant Games, 2012) which collectively varied greatly from those at the Olympic (Olympic.org, 2014) and World Games (International World Games Association, 2014).

What could be extrapolated from the presented data in Table 8 and the studies by Junge *et al.* (2009), Nook and Nook (2011) and Engebretsen *et al.* (2013) is that there seems to be an apparent increase risk of injury in those sports which might be considered endurance sports (such as athletics, badminton, soccer and hockey). Whilst not commonly regarded as a traditional endurance sports (such as marathon running or long distance cycling), when one considers the number of events an athlete might perform in during the course of a single day or the length of a badminton game (at a competitive level and then also in competition conditions) one can see that both require an adequate degree of anaerobic and aerobic fitness (Mayankcham, 2013; Breckenridge, 2007; Knapik *et al.,* 2001; Bell *et al.,* 2000; Chomiak *et al.,* 2000; Hopper *et al.,* 1995; Jones *et al.,* 1993) and can thus be considered endurance sports (Top End Sports, 2014). These sports may therefore present as a risk factor for transplant athletes (Rodino and Shane, 1998; Robergs and Roberts, 1996).

Furthermore, the increased likelihood of injuries occurring in endurance sports is increased due to dehydration experienced by the participating athlete (Mayo Clinic Staff, 2014). Therefore, considering that the majority of athletes in this study who presented to the CTF were kidney transplant recipients (Table 5) and the fact that dehydration as well as age are considered potential complications post transplantation (UC Davis Transplant Centre, 2014; Schonder *et al.,* 2010; Unterman, *et al.,* 2009; Diep *et al.,* 2008), it is not surprising that the majority of injuries were experienced by those older athletes (Table 5) participating in endurance sports in a subtropical, humid environment (Adeogun, 2013; Gagge and Gonzalez, 1996). This predisposition to injury in endurance sports may also be increased by environmental factors associated with dehydration (heat, humidity) (Intermountain Healthcare, 2014; Gregor and Conconi, 2008) which may be a reason for the high injury rate reported in this study.

The sport participated in by the transplant athlete therefore is not the only possible risk factor for injury in transplant recipients. Therefore the next sections will look at other risk factors for injury.

4.7.2 Injury prevalence per previous Injury

Table 9 presents the number and percentage of athletes who reported having suffered any previous injury and/or trauma when reporting to the CTF during the WTG.

Table 9: Injury prevalence and the relation to a history of previous injury[a] and trauma

	History of Previous Injury		History of Previous Trauma	
	Count	Percentage	Count	Percentage
Yes	70	28.3%	31	12.6%
No	154	62.4%	188	76.1%
Missing	23	9.3%	28	11.3%
Total	247		247	

[a] It must be noted that having undergone solid organ transplantation, which all persons eligible for this study would have done, did not qualify as previous injury and was instead captured as a separate entity.

From Table 9 it is evident that a history of previous injury (any musculo-skeletal complaint incurred due to competition and/or training which received medical attention regardless of the consequences with respect to absence from competition or training) (Junge *et al.,* 2008) was not identified as a precursor for injury amongst the majority of the 247 complaints reported by the 153 presenting athletes. Of this athlete group, only 70 (28.3%) reported having suffered previous injury to the anatomical area for which they were subsequently assessed and/or treated at the various CTFs at the WTG.

A history of previous trauma (any complaint that resulted from injury, damage, hurt, wound, bruise, cut, laceration, abrasion or contusion that required medical assistance [Oxford Dictionary, 2014]) showed similar results to those of previous injury, however the number of participants indicating that they had sustained previous trauma, was lower than that of previous injury (Table 9).

Therefore previous injury and previous trauma are not related to injury in this study. This is contrary to the literature which states that strong evidence exists to support the idea that previous injury, particularly when followed by rehabilitation that is inadequate, places the athlete at increased risk of suffering a secondary injury (Seme and Kondric 2013; Alsonso *et al.,* 2012; Verhagen *et al.,* 2004; Chomiak *et al.,* 2000; MacFarlane and Shanks, 1998; Wiesler *et al.,* 1996) or re-injury of the same type and location (Seme and Kondric 2013; Alsonso *et al.,* 2012; Verhagen *et al.,* 2004; Murphy, Connolly and Beynnon, 2003; MacFarlane and Shanks, 1998).

As a result, this serves to re-enforce the possibility that the age of the athlete, along with their transplant type, seem to predispose the athlete injury in endurance related sports (which may be influenced by hydration). This assertion however requires further study in order to confirm this hypothesis.

4.7.3 Injury prevalence per anatomical site

There were up to three complaints per consultation, and multiple anatomical sites per complaint.

For complaint 1, there were 267 sites. The most frequent was thigh (n = 72 or 27% of sites in complaint 1).

For complaint 2, there were 24 sites, the most frequent being the thigh (n = 7 or 29.2% of sites in complaint 2)

There were only two instances where there was a third complaint and these were in the lumbar and shin/calf regions.

From Table 10 it is clear that injuries to the thigh area were the most common in athletes, accounting for 79 (27%) of the total 293 complaints (irrespective of whether it was complaint one, two or three). The next most commonly injured areas of the body were: shin/calf region (n = 60; 20.5%), shoulder (n = 28; 9.6%) and the lumbar regions (n = 27; 9.2%).

Table 10: Distribution of number of complaints per anatomical site

Anatomical Site	Numbers of complaints	Percent of Cases
Thigh	79	27.0%
Shin/Calf	60	20.5%
Shoulder	28	9.6%
Lumbar	27	9.2%
Knee	22	7.5%
Thorax	20	6.8%
Foot/Ankle	20	6.8%
Neck	14	4.8%
Hip	7	2.4%
Wrist/Hand	6	2.0%
Elbow	5	1.7%
Upper Arm	2	0.7%
Forearm	2	0.7%
Other	1	0.3%
Total	293	

The results in this study vary from those of Nook and Nook (2011) who, at the 2009 WG, found that complaints to the following anatomical areas were most commonly reported: lumbar spine (n = 309; 36.2%), thoracic spine (n = 195; 22.8%) and the neck region (n =

139; 22.6%). The shoulder was found to be the fourth most frequently injured site, accounting for less than 10% of total treatments per anatomical region, whereas injuries to thigh represented only approximately 4% of this total (Nook and Nook, 2011).

In a similar manner, Junge *et al.* (2009) found that the most prevalent diagnosis at the 2008 OG were ankle sprains (n = 81; 7.3%) and strains to the thigh (n = 75; 6.8%). Furthermore, of the 1 108 injuries recorded, 600 (54.2%) were to the lower extremity, with the thigh (13.3% the most injured anatomical region of the lower extremity). The studies by Nook and Nook (2011) and Junge *et al.* (2009) are not dissimilar to Grant *et al.* (2014), who found in their study of athlete and non-athlete physiotherapy encounters during the 2012 OG in the main athlete's village polyclinic, that in the athlete group the highest proportion of injuries recorded at the first consultation only (n = 501; 41%) involved the knee (15.4%), followed by the lumbar spine/low back (15.2%), and the upper leg (12.6%). Similarly, Engebretsen *et al.* (2013) found that of the 174 injuries sustained by athletes at the 2012 London Summer OG, 24 (8.19%) were muscle strains of the thigh [which resulted in absence from competition or training for more than one week].

When considering the four studies referred to above (Grant *et al.,* 2014, Engebretsen *et al.,* 2013, Nook and Nook 2011; Junge *et al.,* 2009) the effects of certain underpinning assumptions resulting in the description of typical patients at each of the studied events (OG 2008; WG 2012 and OG, 2012) need to be considered:

1. The effect of the type and number of sports needs to be considered (as discussed in Section 4.7.1).
2. The health care personnel responsible for diagnosis, because the reporting or the type, severity and perceived mechanism of complaint can vary according to the diagnostic scope of a health care professional as well as their ability to treat such presenting conditions. For example the 2009 WG in Taiwan had limited scope for the chiropractors that treated under the banner of the Federation Internationale de Chiropractique du Sport. This was based on the lack of legislation for the practice of Chiropractic in Taiwan (Chapman-Smith, 2000). The report by Grant *et al.* (2014) was limited in that it was compiled by physiotherapists working at these games, which is different from the IOC OG medical report from Junge *et al.* (2009), which involves a multi-disciplinary approach. In this context, this study would be biased to only reporting from a chiropractic vantage point.
3. In addition one needs to consider that Junge *et al.*'s (2009) study showed a propensity for younger athletes (mean – 25.7; Standard Deviation – 4.75),

with an equitable gender distribution [male (54.2%); female (45.8%)], who incurred overuse injuries in 22% of cases, whilst participating in an endurance sport (soccer, taekwondo, hockey). The most common injury was an ankle sprain (7.3%) or thigh strain (6.8%) and that this was most likely to be sustained in competition (72.5%). This contrasts Nook with and Nook (2011), who showed that female athletes (n = 1 250) sought chiropractic more frequently than the males (n = 1 692) (n = 200; 16% and n = 245; 14.8% respectively) and were most likely to receive treatment for either lumbar, thoracic or neck pain more than any other complaint. Similarly, Engebretsen *et al.* (2013) observed the likelihood of injury at the 2012 OG to occur in women more frequently when participating in endurance sports resulting in time loss from sport occurring in 35% (n = 482) of cases. Athletes were most likely to succumb to injury as a result of overuse (n = 346; 25%), particularly in diving and athletics and equally so whether in competition or training. These outcomes may be driven by patient preference (Kopansky-Giles *et al.,* 2010; Pluim *et al.,* 2009; Boon and Kachan, 2008; Sackett *et al.,* 2000).

In addition to the above differences between the reported studies and the results of this study, the fact that this study focussed on transplant athletes also has bearing on the location (region), type and severity of the possible complaints that the athletes may have presented with. Further to this the type of reporting tool or surveillance tool may have had an impact on the manner or style of reporting between previous studies and this one (Brooks and Fuller, 2006; Junge and Dvorak, 2000; Finch, 1997; van Mechelen, 1997), thus resulting in different outcomes.

Therefore it is imperative that these factors are also considered when addressing risk factors for the injuries in athletes / transplant athletes, as the context in which data is collected may influence the outcome of studies and therefore modify risk factors. Thus the next section looks at the injury prevalence in the context of the mechanism of injury for transplant athletes specifically.

4.7.4 Injury prevalence per mechanism of injury

Figure 2 depicts the distribution of injuries as per their recorded mechanism of injury.

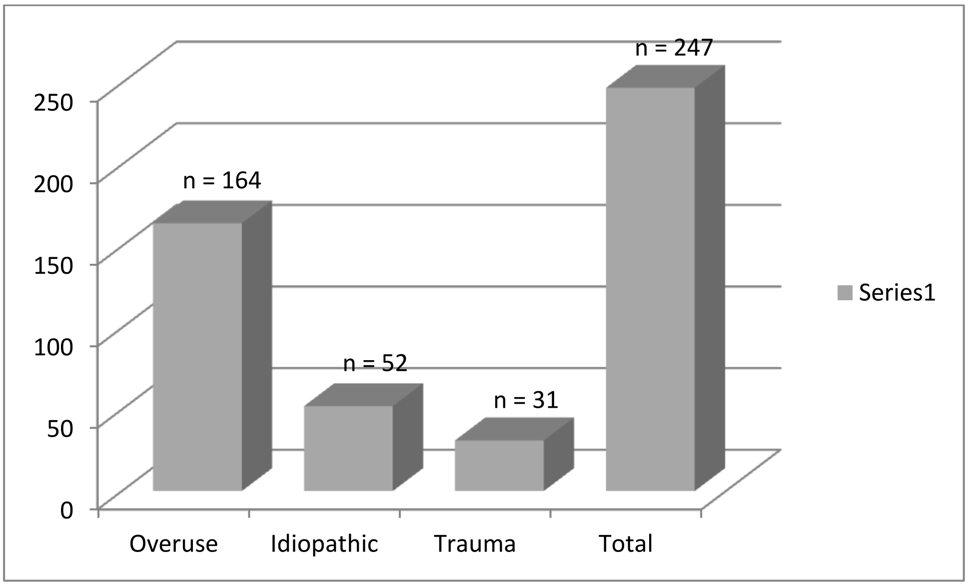

Figure 2: Frequency of all injuries as stratified by their causative mechanism

Mechanism of injury, although variable in its definition, is widely used in medical literature to describe the inciting event of an injury in biomechanical terms (Bahr and Krosshaug, 2005). The degree to which these events are defined often depends on whether or not a biomechanical or epidemiological model is used to describe the interaction between the specific causative factors (Bahr and Krosshaug, 2005).

There are numerous classification systems for identifying the mechanism of injury in the literature (Bahr and Krosshaug, 2005). An example of one such system is that proposed by Seering *et al.* (1980) which suggests seven basic mechanisms of injury: (*a*) contact of impact; (*b*) dynamic overload; (*c*) overuse; (*d*) structural vulnerability; (*e*) inflexibility; (*f*) muscle imbalance; (*g*) rapid growth. This has more recently been adapted by the Committee on Trauma Research which classifies mechanism of injury as follows: (a) crushing deformation; (b) impulsive impact; (c) skeletal acceleration; (d) energy absorption; (e) extent and rate of tissue deformation (Committee on Trauma Research, 1985).

By comparison, the classification system used in this study is far simpler, allowing ease of application by the clinical staff and ease of understanding on the part of the athlete, enabling more accurate collection of data (Korporaal, 2002). A simpler system is necessary particularly in regions were language (Scollen and Scollen, 1995) make it almost impossible to accurately collect data based on the Committee on Trauma Research, (1985) and Bahr and Krosshaug, (2005) classifications. The following three mechanisms of injury were utilised: Trauma, Overuse and Idiopathic.

It is evident, from the data displayed in Figure 2 above, that the majority of injuries sustained by athletes at the 2013 WTG were considered to be due to overuse, with 164 of the 247 (66.4%) complaints having overuse as their causative mechanism. This outcome is higher than that of Engebretsen *et al.* (2013) who found that the four most commonly reported injury mechanisms at the 2012 OG were overuse (n = 346; 25%), non-contact trauma (n = 275; 20%), contact with another athlete (n = 197; 14%) and contact with a stationary object (n = 164; 12%). But contextually, it was also reported by Engebretsen *et al.* (2013) that the majority of injuries were reported to be acute (non-contact trauma [20%], contact with another athlete [14%] and contact with a stationary object [12%]), with overuse injuries (with either gradual or sudden onset) accounting for only 25% of total injuries. This distribution of injuries is similar to that found at the 2008 OG (Junge *et al.,* 2009), but should be interpreted with caution as there are currently limitations in place regarding the definitions applied for overuse injuries (Bahr, 2009).

Therefore, the results of this study collectively suggest that overuse (Figure 2: 66.4%) injuries (of the thigh, shin/calf, shoulder and lumbar regions [Table 10]) in endurance athletes (Table 8 Section 4.7.1) are a common occurrence. The high proportion of endurance injuries in this study may be influenced by the fact that injuries seem to be more common in the older group athlete group (mean age = 56.9; SD6.1 yr) (Matheson *et al.,* 1989), who participate in racquet sports, walking and low intensity endurance sports. This assertion concurs with the work of O'Connor and Wilder (2001), Whiting and Zernicke (1998), Gluten (1997) and Lamb and Murray (1988), where age and the repetitive nature encountered in endurance sports seem to be related to the type or nature of injury reported (DiFiori *et al.,* 2014). The findings of Grant *et al.* (2014) further substantiate these results, as they identified that in 74.65% (n = 374) of 501 athlete physiotherapy first visits were overuse in nature and accounted for 43.6% of injury causes. Non-contact trauma was the next most frequently identified causative mechanism. It therefore also needs to be considered that particularly with transplant athletes (majority kidney – see Table 7) that the causative factors in transplant athletes may not have as linear a relationship as the literature suggested, this is because covariate factors (e.g. kidney transplant, changes in renal metabolism and electrolyte balances) have yet to be considered fully, particularly as Miller *et al.* (2010) suggest that dehydration is linked to an increase in musculoskeletal complications and therefore, possibly injury.

Notwithstanding the outcomes of this research, it is possible that future research may report differently particularly with regards to age and injury prevalence (even in transplant athletes) as this reporting seems to be related to differing definitions of injury, methodological differences between studies and the manner and type of data collected to draw appropriate conclusions. According to Stathokostas *et al.* (2013) it is therefore premature to provide definitive incidence rates, causes, and correlates of physical activity-related injuries for particular athlete populations.

4.7.5 Injury prevalence per clinical impression

The results from Table 11 show that of the 247 complaints by athletes at the WTG, the majority (n = 141; 57.1%) were acute in nature. Injuries that were deemed to be chronic in clinical impression were the next most frequent, accounting for 32.4% (n = 80) of the total.

Table 11: Distribution of injuries according to clinical impression

Clinical Impression	Count	Percentage
Acute	141	57.1%
Chronic	80	32.4%
Sub-acute	25	9.7%
Acute-on-Chronic	1	0.4%
Total	247	

Clinical impression, as it was utilised in this research study, was used to describe the characteristics (rubor, dolor, calor, tumor, functio lasea) (Rippey, 2006) of the injury itself and not the given diagnosis of the athlete's complaint. Clinical impression and its identification is an important aspect of proper patient management as many working diagnoses, especially those affecting the musculoskeletal system, and are developed through a process of exclusion (Amorin-Woods and Parkin-Smith, 2012), particularly when the diagnosis is uncertain. Herein lies the importance of the identification of clinical impression after the exclusion of any serious illness or injury has been carried out (Amorin-Woods and Parkin-Smith, 2012). Rather than focusing on a definitive diagnosis, or labelling the condition, a defendable management plan can be instated, based on the clinician's knowledge of the clinical impression of the complaint, as response to treatment often aids in making or clarifying the diagnosis (Amorin-Woods and Parkin-Smith, 2012).

Based on the inconsistency of terminology between studies of a similar nature, it was not possible to compare outcomes between them in terms of the chronicity of the athlete's complaint (Engebretsen *et al.,* 2013, Junge *et al.,* 2009; Nook and Nook, 2011). This is particularly evident as Engebretsen *et al.* (2013) reported acute to be related with traumatic events, non-contact trauma [20%], contact with another athlete [14%] and contact with a stationary object [12%]), whereas in this study it was based on the presence of rubor, dolor, calor, tumor, functio lasea (Rippey, 2006). The latter signs and symptoms may present in an overuse injury (Figure 2), without the need for a traumatic event as suggested by Engebretsen *et al.* (2013).

When contextualising the chronicity of the athletes' complaints in this study in terms of the age (Table 5), gender (Table 5) and type of transplant (Table 7) as well as the fact that the majority of athletes presented with thigh complaints (Table 10) which were categorised as overuse injuries (Figure 2); it becomes apparent that the most likely diagnoses to be expected in the Section 4.7.7 would be of a muscular type and potentially related to acute spasm, acute muscle irritation and / or significant severe myofascial dysfunction – each of which would comply with the results presented thus far.

4.7.6 Injury prevalence per diagnosis

The distribution of injuries by diagnosis amongst the athlete population who presented to the CTF during the WTG is depicted in Table 12.

Table 12: Frequency of each specific diagnosis amongst athletes presenting to the CTF

Diagnosis	Count	Percentage
Myofasciitis	63	25.5%
Muscle Strain	41	16.6%
Thoracic Facet Syndrome	16	6.5%
Tendonitis (non-specified)	14	5.7%
Muscle Spasm	10	4.1%
Sacroiliac Syndrome	9	3.6%
Lumbar Facet Syndrome	9	3.6%
DOMS[º]	9	3.6%
ITB Syndrome[1]	7	2.8%
Cervical Facet Syndrome	7	2.8%
Joint Sprain: Ankle	7	2.8%
Supraspinatus Tendonitis	7	2.8%
Lymphodema	4	1.6%
Ligament Sprain	4	1.6%
MTSS[3]	4	1.6%

Table 12: continued

Diagnosis	Count	Percentage
Rotator Cuff Tendonitis	3	1.2%
Joint Sprain: Elbow	2	0.8%

Joint Sprain : Knee	2	0.8%
Joint Fixation: Hip	2	0.8%
Bone Bruise	1	0.4%
Capsular Strain: Shoulder	1	0.4%
Head Contusion	1	0.4%
Impingement Syndrome	1	0.4%
Epicondylitis	1	0.4%
Myofascial Pain Syndrome	1	0.4%
Infrapatellar Bursitis	1	0.4%
Prosthetic Knee	1	0.4%
Fat Pad Syndrome	1	0.4%
Fracture: Scaphoid	1	0.4%
Blisters	1	0.4%
Torticolis: Acute	1	0.4%
Hip Dysfunction	1	0.4%
Accessory Lateral Meniscus	1	0.4%
Instability: Knee	1	0.4%
Joint Sprain: Wrist	1	0.4%
Sacroilitis	1	0.4%
Muscle Tear: Supraspinatus	1	0.4%
Patellofemoral Pain Syndrome	1	0.4%
Instability: Knee – Multidirectional	1	0.4%
Subluxation: AC Joint[3]	1	0.4%
Rotator Cuff Tear	1	0.4%
Cuboid Dysfunction	1	0.4%
Ankle Dysfunction	1	0.4%
Suprapatellar Tendon Tear	1	0.4%
Plantar Fasciitis	1	0.4%
Capsulitis: Hip	1	0.4%
Total	247	100.0%

º DOMS – Delayed Onset Muscle Soreness
[1] ITB Syndrome – Iliotibial Band Syndrome
[2] MTSS – Medial Tibial Stress Syndrome
[3] AC Joint – Acromioclavicular Joint

The diagnosis for each individual complaint per athlete was reached after deliberation between the chiropractic student and a qualified, supervising chiropractor (see Section 3.3.1). In Table 12 the frequency of each of the diagnoses across the entire population (n = 153) of athletes who presented to the CTF is depicted.

The two most prevalent diagnoses found throughout the duration of the WTG were those of myofasciitis (n = 63; 25.5%) and Muscle strain (41; 16.6%), which is consistent with the concluding paragraph in Section 4.7.5. This also seems to support the assertion that immune-suppressive drug therapy post transplantation may adversely affects muscle fibres (National Kidney Foundation, 2014; Unterman *et al.,* 2008).

The next most frequently reached diagnoses were: thoracic facet syndrome (n = 16; 6.5%), tendonitis (non-specific) (n = 14; 5.7%), muscle spasm (n = 10; 4.1%) and sacroiliac syndrome, lumbar facet syndrome and delayed onset muscle soreness DOMS all of which accounted for nine cases (3.6%) each.

These results concur with Junge *et al.* (2009) who found that the most prevalent diagnoses at the 2008 Olympic Games were those of ankle sprains and thigh strains. By contrast the results obtained by Engebretsen *et al.* (2013) and Johnson (2013) fail to highlight what the most frequently reached diagnoses in their respective studies. However, in work carried out by Grant *et al.* (2014) at the 2012 OG, which recorded physiotherapy encounters at the Polyclinic in the Main Athlete's Village, some of the most frequent diagnoses for an athlete's first visit were: muscle injuries (33.3%); joint injuries (24.8%); tendinopathy (12.8%); bone injuries (2.0%) and nerve root or spinal cord injury (1.4%).

It is therefore evident that the athletes in this study seemed to present with injuries that were not disabling and therefore it is likely that they would have been able to continue their sport after a relatively short period away from active participation (if that was required), which would not have hindered their ability to compete. Thus, Section 4.7.7 describes the athlete's recorded ability to continue with participation after having been assessed and treated for their complaint.

4.7.7 Ability to continue participation

The majority (90.67%) of athletes were able to continue participation as they sustained a mild injury as compared to the 2.02% that suffered a traumatic event that did not allow continued participation in the WTG. Figure 3 depicts the frequency of athlete ability to continue participation

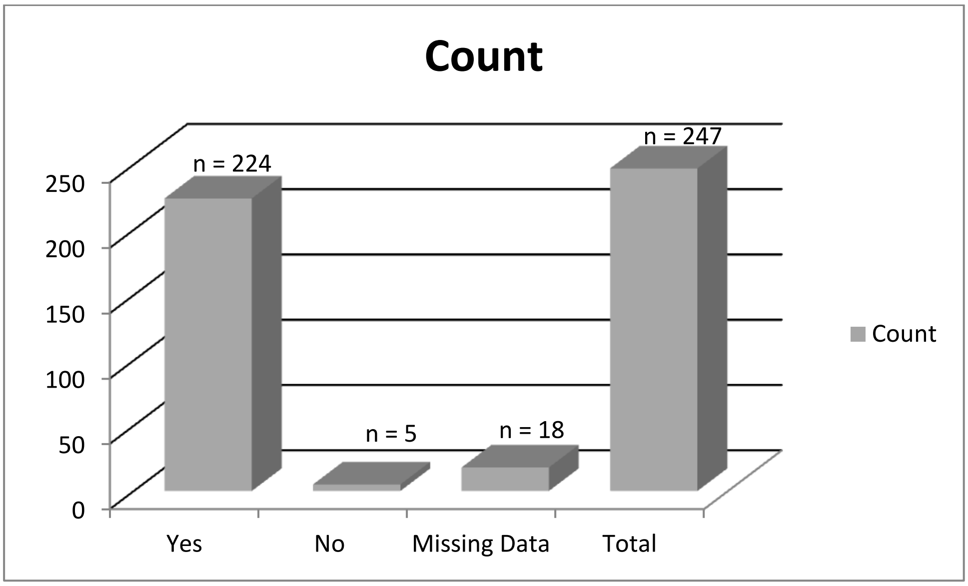

Figure 3: Frequency of athlete ability to continue participation

From Figure 3 it is clear that the large majority (n = 224/247; 90.7%) of injuries sustained by participants at the 2013 WTG were not severe enough to halt participation at the time of competition. Only five cases in which the participant was not able to continue participation included a fractured scaphoid, a severe case of supraspinatus tendonitis, a supraspinatus muscle tear, a rotator cuff tear and an acromioclavicular joint subluxation.

Whilst Junge *et al.* (2009) make no comment on the ability of the athlete to resume competition or training at the time of the injury, they do state that in 49.6% (n = 419) of the cases, where information in relation to time loss from injury was available (n = 844; 80%), the injury was expected to halt or prevent the athlete from further competition or training.

Thus the injury profile results of this study in conjunction with the transplant athletes' demographic profile concur with Matheson *et al.* (1989) who indicated that a high proportion of endurance injuries in their study may be influenced by the fact that injuries seem to be more common in the older group athlete group (mean age = 56.9; SD6.1 yr) who participate in endurance sports. Similarly, when compared to the results of the study by Junge *et al.* (2009), it would seem that younger athletes are more likely to sustain fewer, but more severe injuries as compared to older athletes that sustain more frequent, but less severe injuries that result from overuse. This would agree with the data already presented in Section 4.7.1 where it was suggested that the transplant athletes in this study were older, more likely to participate in endurance related sports codes, were more likely to be kidney transplant patients, with injuries that reflected acute thigh muscle problems that were diagnosed as either myofasciitis, muscle spasm or muscle strain (Table, 5; Table 7; Table 8; Table 10; Table 11; Table 12).

4.7.8 Cross tabulation of organ transplanted and region of complaint

Table 13 presents the frequency of complaints per anatomical region by numbers of individuals with a specified organ transplant.

Table 13: Representation of frequency of complaints per anatomical region by number of individuals with a specific organ transplant

Organ Transplanted	Number of Organs TP	Anatomical Region of Complaint													
		Neck	Shoulder	Elbow	Upper arm	Forearm	Wrist/Hand	Thorax	Lumbar	Hip	Thigh	Knee	Shin/Calf	Foot/Ankle	Other
Kidney	58	4	9	2	1	1	3	5	8	2	34	8	33	6	0
Unknown	37	3	2	2	0	1	0	4	7	1	23	5	13	6	0
Heart	22	0	6	0	0	0	2	0	8	3	7	4	1	3	1
Liver	15	3	8	0	0	0	0	3	4	0	9	2	5	0	0
Lung	12	3	3	0	0	0	1	6	0	1	4	3	4	3	0
Bone Marrow	6	1	0	1	1	0	0	1	0	0	1	0	1	2	0
Stem cells	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Kidney and Pancreas	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Heart and Lungs	1	0	0	0	0	0	0	0	0	0	1	0	2	0	0

An athlete presenting to the CTF may have had multiple complaints at his or her first consultation and subsequent consultations thereafter. Each complaint may have involved one or more anatomical regions with only a single diagnosis given for that particular complaint. Therefore it is possible that, for example, of the six bone marrow transplant athletes there were eight reported anatomical regions of complaint (Table 13).

Table 13 illustrates that the majority of kidney transplant recipient athletes experienced injuries affecting their thigh, which concurs with the conclusions presented at the end of Section 4.7.7.

4.7.9 Cross tabulation of organ transplanted and diagnosis

Table 14 depicts the distribution of each diagnosis in relation to the organ which the presenting athlete would have had transplanted. The data is from all the complaints at all consultations made by all athletes.

Table 14: Frequency distribution of diagnoses per organ transplanted

Diagnosis	Unknown	Kidney	Heart	Bone Marrow	Liver	Lung	Stem Cells	Kidney and Pancreas	Heart and Lungs
Numbers of transplant recipients	37	58	22	6	15	12	1	1	1
Total number of diagnoses	55	92	35	8	29	24	1	1	2
Accessory Lateral Meniscus	0	0	1	0	0	0	0	0	0
Ankle Dysfunction	0	0	0	1	0	0	0	0	0
Blisters	0	0	0	0	0	1	0	0	0
Bone Bruise	0	1	0	0	0	0	0	0	0
Capsular Strain: Shoulder	0	1	0	0	0	0	0	0	0
Capsulitis: Hip	0	0	1	0	0	0	0	0	0
Cervical Facet Syndrome	2	2	0	1	1	1	0	0	0
Cuboid Dysfunction	0	0	0	0	0	1	0	0	0
DOMS º	3	3	1	0	1	1	0	0	0
Epicondylitis	1	0	0	0	0	0	0	0	0
Fat Pad Syndrome	0	1	0	0	0	0	0	0	0
Fracture: Scaphoid	0	1	0	0	0	0	0	0	0
Head Contusion	0	0	1	0	0	0	0	0	0
Hip Dysfunction	0	0	0	0	0	1	0	0	0
Impingement Syndrome	0	0	1	0	0	0	0	0	0
Infrapatellar Bursitis	0	1	0	0	0	0	0	0	0
Instability: Knee	0	1	0	0	0	0	0	0	0
Instability: Knee -Multidirectional	0	0	1	0	0	0	0	0	0
ITB Syndrome [1]	1	2	3	0	1	0	0	0	0
Joint Fixation: Hip	1	0	1	0	0	0	0	0	0
Joint Sprain : Knee	1	1	0	0	0	0	0	0	0
Joint Sprain: Ankle	3	1	2	0	0	1	0	0	0
Joint Sprain: Elbow	1	1	0	0	0	0	0	0	0
Joint Sprain: Wrist	0	1	0	0	0	0	0	0	0
Ligament Sprain	1	0	0	0	1	2	0	0	0

Table 14 continued

Diagnosis	Unknown	Kidney	Heart	Bone Marrow	Liver	Lung	Stem Cells	Kidney and Pancreas	Heart and Lungs
Lumbar Facet Syndrome	1	2	4	0	2	0	0	0	0
Lymphodema	0	4	0	0	0	0	0	0	0
MTSS [2]	1	3	0	0	0	0	0	0	0
Muscle Spasm	1	7	1	0	0	1	0	0	0
Muscle Strain	6	18	7	1	6	1	0	0	2
Muscle Tear: Supraspinatus	0	1	0	0	0	0	0	0	0
Myofascial Pain Syndrome	1	0	0	0	0	0	0	0	0
Myofasciitis	16	28	3	4	7	4	1	0	0
Patellofemoral Pain Syndrome	0	0	1	0	0	0	0	0	0
Plantar Fasciitis	0	0	0	1	0	0	0	0	0
Prosthetic Knee	1	0	0	0	0	0	0	0	0
Rotator Cuff Tear	0	0	0	0	0	1	0	0	0
Rotator Cuff Tendonitis	0	2	1	0	0	0	0	0	0
Sacroiliac Syndrome	5	2	1	0	1	0	0	0	0
Sacroilitis	0	1	0	0	0	0	0	0	0
Subluxation: AC Joint [3]	0	0	0	0	0	1	0	0	0
Suprapatellar Tendon Tear	0	0	0	0	0	1	0	0	0
Supraspinatus Tendonitis	0	0	2	0	5	0	0	0	0
Tendonitis	5	5	2	0	1	1	0	0	0
Thoracic Facet Syndrome	4	2	1	0	3	5	0	1	0
Torticolis: Acute	0	0	0	0	0	1	0	0	0

[º] DOMS – Delayed Onset Muscle Soreness
[1] ITB Syndrome – Iliotibial Band Syndrome
[2] MTSS – Medial Tibial Stress Syndrome
[3] AC Joint – Acromioclavicular Joint

The number of diagnoses reached per organ transplanted are not equal as the number of individuals presenting to the CTF who had undergone kidney(s) transplantation was far higher than, for example, the number of participants who had undergone combined heart and lung transplantation. Subsequently, the results obtained are not directly comparable to one another, not even proportionately, as in some cases there was only one participating athlete with one particular organ transplanted.

Table 15 below is a distilled version of Table 14 which highlights the most frequent diagnoses per organ transplanted.

Table 15 illustrates that the majority of kidney transplant recipient athletes experienced proportionately more injuries affecting their muscles, which concurs with the conclusions presented at the end of Section 4.7.6. Muscle strains were particularly prevalent amongst those athletes who had undergone kidney and heart transplantation, with this diagnosis accounting for 31.03% (n = 18) and 31.28% (n = 7) in the respective athlete groups.

Table 15: Most frequent diagnoses per organ transplanted

Organ Transplanted	Number of athletes with specific OTP	Most frequent diagnosis	Count	Percent
Kidney	58	Myofasciitis	28	48.3%
		Muscle Strain	18	31.0%
		Muscle Spasm	7	12.1%
Heart	22	Muscle Strains	7	31.8%
		Lumbar Facet Syndrome	4	18.2%
		ITB Syndrome	3	13.6%
Bone Marrow	6	Myofasciitis	4	66.7%
		Cervical Facet Syndrome	1	16.7%
		Muscle Strain	1	16.7%
Liver	15	Muscle Strain	6	40.0%
		Myofasciitis	4	26.7%
		Thoracic Facet Syndrome	2	13.3%
Lung	12	Myofasciitis	4	33.3%
		Thoracic Facet Syndrome	4	33.3%
		Muscle Strain	2	16.7%
Stem Cells	1	Myofasciitis	1	100.0%
Kidney + Pancreas	1	Thoracic Facet Syndrome	1	100.0%
Heart and Lungs [1]	1	Muscle Strain	2	

[1] Records from a sole participant with combined Heart and Lung transplants were captured in this study. This patient returned to the CTF twice and was diagnosed with the same diagnosis on both occasions.

The outcomes of Table 14 and Table 15 reinforce the assertion that the kidney transplant athletes had a higher likelihood for problems with mineral and electrolyte control, particularly in the environment in which the WTG took place (subtropical, humid and warm). This placed increased pressure on these athletes in order to control their electrolyte metabolism in endurance events which did not allow for periodic breaks or appropriate rehydration at regular intervals (athletics, competition in multiple sports, badminton and cycling [the majority of which were outdoors]) (Mayo Clinic Staff, 2014; Intermountain Healthcare, 2014, Miller *et al.,* 2010; Gregor and Conconi, 2008). It is likely in these circumstances that in order to maintain body homoeostasis the body would have diverted required electrolyte concentrations from organs that were perceived not to require the electrolytes as a necessity to those vital organs that are life sustaining (Casa, Clarkson and Roberts, 2005; Institute of Medicine, 2005). As a result it is likely that muscles would have suffered negative consequences of this physiological process, resulting in clinically diagnosed Myofasciitis ("heat cramps"), muscle spasm ("cramps") or muscle strain (King, 2004). Dependent on the degree of the electrolyte imbalance the presentation of the condition may have been perceived to be more acute than chronic in nature (Rippey, 2006).

This outcome needs further testing, but is an important start in understanding the transplants athletes physiological, biological and psychological needs, the effects of exercise and environmental challenges in which these occur, as this shapes the types of injuries that may befall an athlete during athletic activity (Hyde and Gengenbach, 2007).

4.7.10 Cross tabulation of the region of complaint and clinical impression

As per the results displayed in Table 16 below, it is evident that the majority of injuries encountered by athletes during the WTG were acute in nature.

Table 16: Clinical impression of complaints per anatomical region

Anatomical Region of Complaint	Clinical Impression			
	Acute	Chronic	Sub-acute	Acute on chronic
Thigh	38	30	11	0
Shin/Calf	36	18	6	0
Foot/Ankle	15	3	2	0
Shoulder	14	12	2	0
Knee	13	8	1	0
Neck	10	4	0	0
Thorax	10	9	1	0
Lumbar	10	13	3	1
Elbow	5	0	0	0
Wrist/Hand	4	1	1	0
Hip	4	2	1	0
Upper arm	2	0	0	0
Forearm	2	0	0	0
Other	1	0	0	0
Total	164	100	28	1

Clinical impression, as utilised in this study, referred to the injury that the athlete would have presented with, rather than serving as a declaration of the state of the patient as a whole (Neligan, 2001).

The classification of injuries is a widely varying and at times confusing process. The imprecision of classifying acute and chronic injuries is evident in the numerous treatment approaches often employed by health care providers (Knight, 2008). An example of this is how both recurrent acute injuries as well as overuse injuries are considered chronic, by definition (Merriam-Webster Dictionary, 2014).

The classification system used in this study included the categories as depicted above in Table 16. Due to the diverse and discordant manner in which injuries are currently classified, the results of this study may not be directly comparable to those obtained at various other sporting events. This is further substantiated in the work compiled by Junge *et al.* (2008) in which they state that even though injury surveillance studies have been reported for a number of different sports, comparison of the results of these studies is not feasible due to the heterogeneous injury definitions, methods of data collection, observation periods, study designs and sample characteristics (Brooks and Fuller, 2006; Junge and Dvorak, 2000; Finch, 1997; van Mechelen, 1997).

The results obtained in this study show that for three of the four injury categories (acute, chronic and sub-acute) injuries were most frequently encountered in the thigh and shin/calf regions. Injuries affecting the thigh from these three categories accounted for 79 (26.7%) of the total 263 complaints. The shin/calf region accounted for a further 60 (20.5%) of injuries in the acute, sub-acute and chronic categories. This concurs with the high numbers of reported myofasciitis, muscle strain and muscle cramp diagnoses that were reported in this study as seen in Table 12 and it agrees with Table 8, which indicates that the sporting codes involved with the majority of injuries predominantly require the use of the lower extremity for purposes of participating in the activity.

The results of this study indicate that transplant athletes, participating in a subtropical humid environment are likely to suffer muscular injuries to the thigh / shin / calf region, that is likely to be diagnosed as a myofascial problem with / without concomitant joint dysfunction; particularly if they are older, white males who have had a kidney transplant and participate in the longer outdoor endurance sports, where regulation of fluid intake may be managed poorly by the athlete (particularly athletics [track], cycling, multisport participation and badminton) and / or the demand for fluid / electrolyte consumption is increased due to the number, duration and / or participation levels over the days of the competition.

This profile however requires further validation through prospective studies that look at larger sample groups of transplant athletes in order to conclusively define the strength of the relationships between these multiple variables / co-variables and how they interact with each other. This would allow for more effective management of injuries and allow for the development of prevention strategies for the athletes to avoid injury (Finch and Cook, 2013; Junge *et al.,* 2008 Ramasamy, Hill and Clasper, 2009; Hyde and Gengenbach, 2007).

4.8 Objective 3: Results and discussion

To determine the treatment profile used in the management of patients who presented to the DUT Chiropractic treatment facilities.

4.8.1 Distribution of treatments utilised

Table 17 depicts the frequency with which each treatment intervention was utilised throughout the duration of the 2013 WTG.

Table 17: Distribution of treatments utilised at the CTF during the WTG

Treatment Type	Count	Percent
Massage	167	32.1%
Ischemic Compression	85	16.3%
Manipulation	70	13.4%
Stretch – PNF [1]	68	13.1%
Mobilisation	52	9.9%
Strapping	34	6.5%
Stretch - Static	26	4.9%
Other	9	1.7%
Ice	5	0.9%
Referral	5	0.9%
Total	521	100.0%

[1] PNF – Proprioceptive Neuromuscular Facilitation

The total figure represents the total number of treatment interventions carried out to all athletes, at all consultations for all complaints. The treatments delivered were in line with the scope of practice of chiropractors in South Africa (Allied Health Professions Act 63 of 1982 as amended). The only modality commonly utilised that was not employed at the WTG was dry needling. This was due to the nature of the patients that were being treated at the WTG (transplant recipients) and in order to reduce risk to the patient in the form of infection, inducing bruising or bleeding and / or unnecessary reactive inflammatory processes.

The findings reveal that massage (32.1%), ischemic compression (16.3%) and manipulation (13.4%) were the three most commonly used forms of treatment intervention. These three modalities were possibly utilised more often in order to address issues of muscle contraction ("spasms") (Table 12) most effectively (Crane *et al.,* 2012; Weerapong, Hume and Kolt, 2005). The choice of massage may also have been considered due to its effects in assisting with the regulation of fluid movement in the body and the ability of massage to aid in drainage of areas of reactivity (acute muscle spasm) in order to restore normal function (Hyde and Gengenbach, 2007; Cheung *et al.,* 2003).

The results pertaining to treatment utilisation at the WTG were similar to those observed at the 2012 OG by Grant *et al.* (2014). The results obtained by Grant *et al.* (2014) are based on the use of physiotherapy services only at the main athlete's village polyclinic in Stratford. The authors found that treatment that was administered depended and varied according to the diagnosis. For diagnoses pertaining to muscle injury in athletes only, treatment massage (33.3%), mobilisation (10.6%), cryotherapy (10.6%) and acupuncture (8.3%) were utilised most frequently. In the event that an athlete was diagnosed with a joint injury, mobilisation (27.2%), joint manipulation (21.7%), massage (13%) and cryotherapy (8.7%) were the treatment modalities most often utilised. Tendinopathy occurring in athletes was treated most frequently with treatment massage (28.6%), ultrasound (12.2%), alter G (10.2%) and mobilisation (10.2%).

The results obtained in this research paper were, however, markedly different to those obtained by Nook and Nook (2011). These authors found that at the 2009 WG Chiropractic manipulations were administered to 68.3% (n = 583) of treated athletes. Mobilisations were utilised in 24.5% (n = 209) of athlete treatments whilst 74.9% (n = 640) of athletes received myotherapy (a form of physical therapy used to treat or prevent soft tissue pain and restricted joint movement caused by muscle or myofascial dysfunction) (Better Health Channel, 2014).

This difference between Nook and Nook (2011), Grant *et al.* (2014) and this study may lie in the fact that the former study reported regions of complaint to be predominantly spinal whereas this study reported the region of complaint to be related predominantly to the lower extremities (Table 10). In addition it must also be considered that:

1. The scope of practice of the health care professionals delivering the respective services may have been and would have depended on the mandate extended to each of the health care professional teams (Nook and Nook, 2010; Nook and Nook, 2011; Grant *et al.,* 2014). An example of this was the restrictions in the modalities that were utilised in the treatment of the athletes based on the presentation of the patient or the patient population (e.g. limitations on dry needling at the WTG as compared to other games,

when this modality is within the scope of practice for South African chiropractors (Allied Health Professions Act 63 of 1982 as amended).

2. The athlete constraints were different, implying that different athlete groups have different indications and contra-indications for care (e.g. the application of manipulation would have been less frequent in the transplant athlete group than a normal athlete group and this would have been decided based on the length of time that the patient had been on cortisone or cortisone derived medication) (Lindsay, 2004; Fahrleitner *et al.,* 2002; Shane, *et al.,* 1997).
3. Lastly the type of treatment applied to the athlete would also have been dictated by the known research literature that exists for that group of athletes, thereby not only addressing injury management but also performance in athletes that have no injury. For example at the WG athletes may have wanted to be manipulated as they may have perceived this to be something that would aid their performance, in the context of the transplant athlete this underlying assumption may not have been present (Zbroch *et al.,* 2012, Dong *et al.,* 2012, Frisch *et al.,* 2009; Prasad *et al.,* 2003).

In addition to the above, limitations of different professional reporting and recording systems utilised to document patient care at various sporting events may have resulted in different outcomes. Recording and reporting of patient information by single or multiple users of the recording systems may produce variation as increased users may result in differences of interpretation by these users (Scollen and Scollen, 1995) and therefore variance in the documented patient data.

4.8.2 Distribution of treatment utilised per diagnosis

Table 18 highlights which treatment modalities were most frequently utilised when addressing each specific clinical diagnosis. As previously discussed under Section 4.8.1, massage was the most frequently used treatment method across the entire athlete population.

Table 18: Frequency of each treatment modality utilisation per clinical diagnosis

Diagnosis	Ice	Manipulation	Mobilisation	Massage	Stretch - PNF	Stretch - Static	Ischemic Comp	Strapping	Other	Referral
Accessory Lateral Meniscus	0	1	1	0	0	0	0	0	0	0
Ankle Dysfunction	0	0	0	1	0	0	0	1	0	0
Blisters	0	0	0	0	0	0	0	0	1	0
Bone Bruise	0	0	0	1	0	0	0	0	0	1
Capsular Strain: Shoulder	0	0	0	1	1	0	0	0	0	0
Capsulitis: Hip	0	0	1	0	0	0	0	0	0	0
Cervical Facet Syndrome	0	7	0	5	1	1	1	0	0	0
Cuboid Dysfunction	0	1	0	1	0	0	0	0	0	0
DOMS º	0	0	3	8	3	1	2	0	0	0
Epicondylitis	0	0	0	0	0	0	0	1	0	0
Fat Pad Syndrome	0	0	0	0	0	0	0	1	0	0
Fracture: Scaphoid	0	0	0	0	0	0	0	0	0	1
Head Contusion	1	0	0	0	0	0	0	0	0	0
Hip Dysfunction	0	1	0	1	0	1	0	0	0	0
Impingement Syndrome	0	0	1	1	0	0	0	0	0	0
Infrapatellar Bursitis	0	0	0	0	0	0	0	1	0	0
ITB Syndrome [1]	0	0	1	6	3	1	3	1	0	0
Joint Fixation: Hip	0	0	2	1	1	0	0	0	0	0
Joint Instability: Knee	0	0	0	0	0	0	0	1	0	0
Joint Sprain: Ankle	1	4	3	3	1	1	0	4	0	0
Joint Sprain: Elbow	0	0	0	1	0	0	0	1	0	0
Joint Sprain: Knee	0	0	1	0	1	0	1	1	0	0
Joint Sprain: Wrist	0	0	0	0	0	0	0	1	0	0
Ligament Sprain	1	0	1	1	0	0	0	3	0	0
Lumbar Facet Syndrome	0	7	3	7	3	1	3	0	0	0
Lymphodema	0	0	1	4	0	0	0	0	0	0
MTSS [2]	0	0	0	3	2	0	2	2	1	0
Multidirectional Knee Instability	0	1	0	0	0	0	0	1	0	0
Muscle Spasm	0	0	0	9	7	1	1	0	0	0
Muscle Strain	1	8	6	30	15	4	18	5	1	0
Muscle Tear: Supraspinatus	0	0	0	0	0	0	0	0	0	1
Myofascial Pain Syndrome	0	0	0	0	0	0	0	0	0	1
Myofasciitis	0	10	10	58	21	9	34	1	0	0
Patellofemoral Pain Syndrome	0	1	1	0	0	0	0	0	0	0
Plantar Fasciitis	0	0	0	1	1	0	0	0	0	0
Prosthetic Knee	0	0	0	0	0	0	0	1	0	0
Rotator Cuff Tear	0	0	0	0	0	0	0	1	0	1
Rotator Cuff Tendonitis	0	1	1	2	1	1	2	0	1	0

Table 18 continued

Diagnosis	Ice	Manipulation	Mobilisation	Massage	Stretch - PNF	Stretch - Static	Ischemic Comp	Strapping	Other	Referral
Sacroiliac Syndrome	0	8	2	6	2	1	2	0	0	0
Sacroiliitis	0	0	1	0	1	0	1	0	0	0
Subluxation: AC Joint [3]	0	0	0	1	0	0	0	1	0	0
Suprapatellar Tendon Tear	1	0	0	0	0	0	0	1	0	0
Supraspinatus Tendonitis	0	2	5	2	1	1	5	1	0	0
Tendonitis: Not Specified	0	1	6	6	2	1	5	3	5	0
Thoracic Facet Syndrome	0	16	2	7	1	1	4	0	0	0
Torticolis: Acute	0	1	0	0	0	1	1	1	0	0

º DOMS – Delayed Onset Muscle Soreness
[1] ITB Syndrome – Iliotibial Band Syndrome
[2] MTSS – Medial Tibial Stress Syndrome
[3] AC Joint – Acromioclavicular Joint

Table 18 identifies that massage was the utilised in 26 (56.5%) of the total 46 diagnoses. Of the 46 diagnosis, at least 26 can confidently be categorised as soft tissue injuries (any injury to the soft tissues of the body, such as: muscles, tendons, ligaments, fascia, nerves, fibrous tissues, fat, blood vessels, and synovial membranes [Sports Medicine Australia, 2014]). The frequency with which massage was then utilised as a treatment modality is validated, as it is well documented that massage achieves favourable results in the treatment of soft tissue injuries (Hyde and Gengenbach, 2007; Chaitow and DeLany, 2000; Travell and Simmons, 1999). There are only five diagnoses (19.2%) for which massage was not more frequently utilised than another treatment modality. These diagnoses in these cases were: cervical facet syndrome, thoracic facet syndrome, sacroiliac syndrome, joint sprain: ankle and supraspinatus tendonitis. In each of these five cases, either joint manipulation or mobilisation were the most frequently employed treatment modalities, which in chiropractic terms for these conditions would be more appropriate (Dagenais and Haldeman, 2012; Brantingham *et al.,* 2012; Brantingham, 2011; Brantingham *et al.,* 2009; Hurwitz *et al.,* 2002; Giles, 1998). These findings are supported by Grant *et al.* (2014) who found that in the event an athlete at the 2012 OG sustained a joint injury, the most likely treatment modalities utilised were: mobilisation (27.2%), joint manipulation (21.7%), massage (13%) and cryotherapy (8.7%) . This further goes to support the findings discussed around Table 17.

4.8.3 Distribution of treatment utilised per clinical impression

Table 19 clearly shows that massage was the most frequently used treatment modality across all categories of clinical impression. Ischemic compression was shown to be the next most frequently utilised modality, followed by manipulation. These results are supported by the data presented in Table 12, which indicates that the majority of injuries sustained by athletes at the WTG were of a muscular nature, with the three most commonly diagnosed muscular injuries (Myofasciitis, Muscle Strains and Muscle Spasm), accounting for a combined total of 46.05% of all diagnoses.

Table 19: Description of the frequency in which the various treatment modalities were used according to the classification of the diagnosis

Clinical impression	**Ice**	**Manipulation**	**Mobilisation**	**Massage**	**Stretch PNF**	**Stretch Static**	**Ischemic Comp**	**Strapping**	**Other**	**Referral**
Acute	4	37	29	99	46	20	44	23	4	5
Acute on chronic	0	1	1	1	0	0	0	0	0	0
Chronic	1	25	15	48	17	6	33	9	4	0
Sub-acute	0	7	7	19	5	0	8	2	1	0

Further substantiation of these findings is evident in the research compiled by Grant *et al.* (2014) whose research showed that in the event of a muscle injury being experienced at the 2012 OG, the most frequently employed treatment modalities were: treatment massage (33.3%), mobilisation (10.6%), cryotherapy (10.6%) and acupuncture (8.3%). Similarly, joint injury was most often treated with a combination of mobilisation (27.2%), joint manipulation (21.7%), massage (13%) and cryotherapy (8.7%). The results obtained in this study are therefore comparable and similar to those internationally (Dagenais and Haldeman, 2012; Brantingham *et al.,* 2012; Brantingham, 2011; Brantingham *et al.,* 2009; Hurwitz *et al.,* 2002; Chaitow and DeLany, 2000; Travell and Simmons, 1999; Giles,1998). The results were also to be expected based on the type and frequency of muscular injury afflicting athletes at the WTG in comparison to other musculoskeletal injuries (please refer to the appropriate tables).

4.8.4 Ability to continue play

Figure 4 displays the distribution of athletes who were permitted to continue or not continue participation after having presented to the CTF.

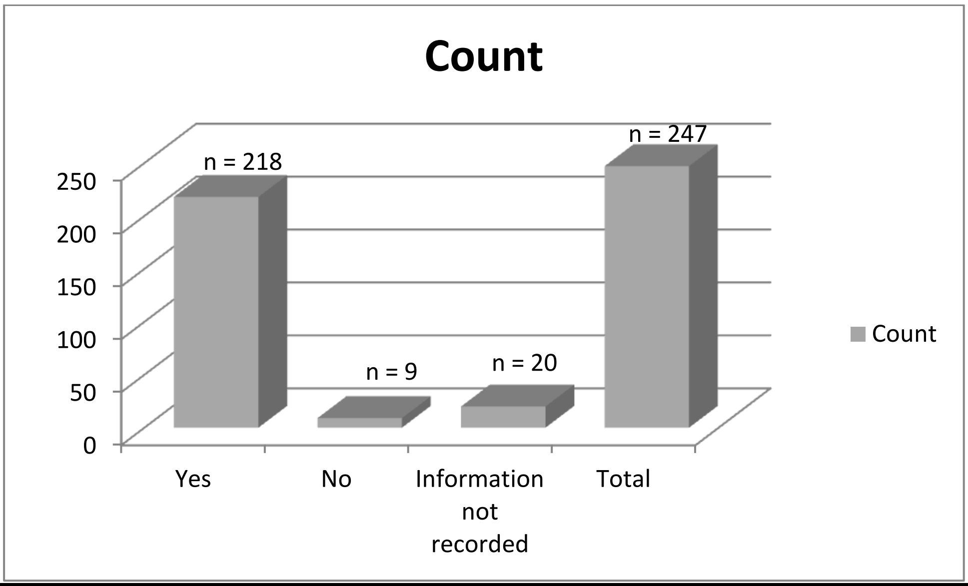

Figure 4: Distribution of permission to continue competing post the chiropractic consultation

The nine cases in which return to or continuation of play/competition was not permitted included: one case of ITB syndrome; two cases of lumbar facet syndrome, a single case of thoracic facet syndrome and one case each of a scaphoid fracture, suprapatellar tendon tear, supraspinatus muscle tear, rotator cuff tear and a subluxation of the AC Joint.

The majority of cases (n = 218; 88.3%) that were treated throughout the duration of the event were not serious enough to prevent or at least warrant a recommendation of ceasing further competition/participation.

By contrast Junge *et al.* (2009) indicated that an injury was likely to halt or prevent an athlete from further competition or training in 49.6% of cases (Section 4.7.7). Junge *et al.*'s (2009) results are slightly higher than those obtained by Engebretsen *et al.* (2013) who found that 65% (n = 879) of injuries incurred by athletes did not result in any time loss from sport. The remaining 35% (n = 482) of injuries were expected to result in an athlete not being able to participate in competition or in training (Engebretsen *et al.,* 2013). The higher rate of lost time due to injury in Junge *et al.*'s (2009) study may be linked to the ages of the participants in that study who tended to be younger (and more likely to sustain more severe injuries [Matheson *et al.,* 1989]) than those in this and Engebretsen *et al.*'s (2013) study. Further to this it was noted in Section 4.6.2 that these younger participants were also more likely to have more severe injuries and therefore this could result in a greater likelihood for preventing further participation in their sports and / or increased time lost due to injury.

This is highlighted in Engebretsen *et al.*'s (2013) explanation where it was estimated that absence from sport participation and training for a period of one to three days would occur in 18% (n = 246 of 879) of cases, whereas 5% (n = 62) would result in absence of between four to seven days. More serious injuries resulting in an absence from participation for eight to twenty-eight days or more than twenty-eight days occurred in 8% (n = 105) and 5% (n = 69) of cases respectively. The most common causes of prolonged absence from participation (more than seven days; n = 174) were: muscle strains; fractures; tendon ruptures; ligament sprains and ligament ruptures. This would therefore agree with the results of this study, where although the athletes suffered acute injury, these injuries were easily remedied based on simple interventions primarily directed at maintaining homoeostasis (Casa, Clarkson and Roberts, 2005; Institute of Medicine, 2005; King, 2004).

4.9 Objective 4: Results and discussion

To passively track each individual participant who presented to the DUT Chiropractic treatment facilities, throughout the duration of the seven days of competition, by analysing their recorded clinical data from the WTG form(s).

4.9.1 Participant tracking

Table 20 below displays the data from those athletes who presented to the CTF on more than one occasion and who also experienced a change in diagnosis during these multiple consultations to the CTF.

Table 20: Depiction of athlete clinical data in those cases where the diagnosis did not remain constant over multiple consultations

Diagnosis changed																
Participant	**Competition Day**	**Visit number**	**Nature of visit**	**Diagnosis**	**Able to continue participation**	**Ice**	**Manipulation**	**Mobilisation**	**Massage**	**Stretch/PNF**	**Stretch Static**	**Ischemic Comp**	**Strapping**	**Other**	**Referral**	**Continuation of Play permitted**
A 1	4	1	1	8	0				1							1
	4	2	4	1	2				1	1		1				1
A8	4	1	1	6	2		1	1	1							1
	5	2	2	6	2				1	1		1				1
	7	3	3	8	2							1				1
B6	6	1	1	8	2				1	1		1				1
	7	2	2	12	2								1			0

Table 20 continued

Participant	Competition Day	Visit number	Nature of visit	Diagnosis	Able to continue participation	Ice	Manipulation	Mobilisation	Massage	Stretch/PNF	Stretch Static	Ischemic Comp	Strapping	Other	Referral	Continuation of Play permited
B10 Complaint 1	5	1	1	8	2		1		1							1
B 10 Complaint 2	6	2	2	2	2		1		1							1
	6	2	2	3	2		1		1							1
C 4	4	1	1	5	2		1	1	1	1						1
	4	2	2	19	2			1	1	1						1
D 7	6	1	1	22	2			1	1							1
	7	2	3	55	2		1	1								1
D 8 Complaint 1	5	1	1	2	2		1		1							1
	6	2	2	59	2		1		1							1
D 8 Complaint 2	6	2	2	3	2		1		1							1
E 1	4	1	1	20	2				1	1						1
	5	2	2	13	2			1	1	1		1				2
	6	3	4	13	2		1	1	1							2
	6	4	4	13	2				1	1		1				1
E 2	2	1	1	8	0								1			1
	2	2	3	5	2		1		1							1
	4	3	4	26	2								1	1		1
F 1	3	1	1	29	2								1			1
	3	2	3	6	2				1	1		1				1
	7	3	4	8	2	1			1	1						1
H 15	2	1	1	3	2		1									1
	5	2	3	24	2								1			1
H 17	3	1	1	6	2				1		1					1
	5	2	2	1	2				1	1						1
	6	3	4	15	2				1			1				1
	6	4	4	15	2				1			1				1
J 9	2	1	1	8	2				1	1			1			1
	5	2	3	8	2				1			1				0
	6	3	3	1	2				1		1					1
	6	4	4	6	2				1			1				1
	7	5	4	8	2								1			1
K 1 - Complaint 1	3	1	1	8	2		1		1					1		1
	5	2	3	26	2			1	1			1		1		1
	6	3	2	10	2			1	1	1		1				1
	7	4	2	10	2		1	1				1				1

Table 20 continued

Participant	Competition Day	Visit number	Nature of visit	Diagnosis	Able to continue participation	Ice	Manipulation	Mobilisation	Massage	Stretch/PNF	Stretch Static	Ischemic Comp	Strapping	Other	Referral	Continuation of Play permitted
K1 - Compliant 2	7	4	2	6	2		1					1				1
K1 - Compliant 3	7	4	2	6	2				1			1				1
K 8	2	1	1	13	2		1		1	1						1
	6	2	3	1	2			1	1	1		1				1
	7	3	3	31	2				1							0
L 4 - Complaint 1	5	1	1	8	2		1					1				1
	6	2	2	13	2		1		1		1	1				1
	6	3	4	6	2				1			1				1
	7	4	3	37	2								1			1
L 4 - Complaint 2	7	4	3	26	2			1	1							1
M 9 Complaint 1	3	1	1	39	1										1	2
	5	2	3	2	0		1		1			1				1
M 9 Complaint 2	5	2	3	3	0		1		1			1				1
M 15 Complaint 1	4	1	1	10	2			1				1				1
	6	2	3	5	2			1				1				1
M 15 Complaint 2	6	2	3	6	2				1							1
M 21	4	1	1	26	2			1	1					1		1
	6	2	3	6	2		1		1							0
M 24	1	1	1	42	2									1		1
	2	2	2	7	2			1	1		1					1

A trend from the pattern of diagnoses as seen above is that the changing diagnoses were most often related to one another, either in terms of anatomical structure or the musculoskeletal system involved. For example, athlete A1 was diagnosed with a muscle strain at his/her first consultation, which was subsequently changed to a diagnosis of ITB syndrome at his/her second consultation.

Whilst there are numerous examples of the diagnoses having inherent similarities, there are those instances where a diagnosis has changed considerably. This is most likely due to the athlete presenting with an altogether different complaint on the second/follow-up consultation to the CTF. This may have been as a result of a different sport (Table 8) in which the athlete participated in. It may however also have been as a result of varying environmental influences (Intermountain Healthcare, 2014; Gregor and Conconi, 2008; van Mechelen, Hlobil and Kemper, 1992) or traumatic events whilst participating in the same sport or a different sport in which traumatic injuries are more likely. This latter assertion may be related to the fact that some participants knowingly entered sports that they had not prepared for, thus increasing their chances for injury (as a result of a lack of sport specific training and endurance) (Orchard, 2001; Norton, Schwerdt and Lange, 2001; Gagge and Gonzalez, 1996; Adeogun, 2013).

This approach also allows for the analysis of injury changes. This arises from the broad definition of an injury (Junge *et al.,* 2008) which allowed the chiropractic student and their supervising clinician to assess patients based on their collective experience to arrive at a diagnoses. This allowed accurate diagnoses to be detailed without being restricted by categories of injury or disease. This approach therefore allowed the impact of injuries across the entire spectrum, from mild contusions to fractures (Hodgson *et al.,* 2007; Junge *et al.,* 2004) to be present and therefore be reflected in Table 20. The benefit herein lies in the importance of assessing the consequences of injuries in the long term, as analysis shows that moderate and major injuries are often precipitated by minor injuries (Ekstrand and Gillquist, 1983). Furthermore, it has been shown that acute injuries may often serve as a predictor of subsequent injuries (Dvorak *et al.,* 2000), and it is not uncommon to encounter athletes who choose to compete despite having an injury (Harringe, Lindblad and Werner, 2004).

However in a study of this nature (viz. retrospective), the broad definitions related to injuries and the nuances associated with the pathogenesis of injuries makes reviewing the reported data (e.g. diagnoses) more complex as it is not possible to interpret the data in a standardised manner. This implies that one needs to accept trends with caution as the variance between data on the report forms has many influencing factors that bear down on it and which would not have been standardised as is possible in a prospective study. As a result most retrospective studies are descriptive in nature and provide trends for future prospective studies (Mouton, 1996). Notwithstanding this limitation, it is generally accepted that anyone placed in a responsibility of caring for another (e.g. the chiropractic student for the athlete at the WTG) would attempt to diagnose and document the most appropriate diagnosis as this would dictate the most appropriate, effective and efficient care (Patient's Rights Charter, 2012). It is therefore not unexpected that Table 22 (below) also reflects diagnoses that were commonly attained by multiple chiropractic students and their supervising clinician at multiple venues on multiple days, for the same athlete.

Table 21 displays the data from those athletes who presented to the CTF on more than one occasion and had no change in diagnosis during these multiple consultations to the CTF.

Table 21: Depiction of athlete clinical data in those cases where the diagnosis remained constant over multiple consultations

Participant	Competition Day	Consultation number	Diagnosis	Able to continue participation	Manipulation	Mobilisation	Massage	Stretch/PNF	Stretch Static	Ischemic Comp	Strapping	Other	Referral	Continuation of Play permited
B14	4	1	3	2	1					1				1
	6	2	3	2	1									1
	7	3	3	2	1	1								1
	7	4	3	2	1					1				1
D 6 complaint 1	4	1	3	2	1									1
	7	2	3	2	1									1
D 6 complaint 2	4	1	13	2	1									1
	7	2	13	2	1									1
B15	3	1	5	2	1		1	1						1
	4	2	5	2	1		1							1
C 1	6	1	18	2			1				1			1
	6	2	18	2		1					1			1
C 2	5	1	6	2			1							1
	5	2	6	2			1							1
D 3	3	1	6	2			1							1
	3	2	6	2			1			1				1
C 10	4	1	8	2			1			1				1
	4	2	8	2				1						1
	6	3	8	2		1		1		1				1
C 12	4	1	8	2	1		1		1					1
	4	2	8	2	1		1		1					1
D 1	6	1	8	2			1	1						1
	7	2	8	2						1				1
H 14	5	1	8	0		1	1			1				1
	5	2	8	0		1	1							1
N 6	6	1	8	2			1	1						1
	6	2	8	2				1		1				1
B 2	1	1	10	1		1			1	1				1
	2	2	10	2							1			1
V 7	4	1	10	2	1		1			1				1
	5	2	10	2		1								1

Table 21 continued

Participant	Competition Day	Consultation number	Diagnosis	Able to continue participation	Manipulation	Mobilisation	Massage	Stretch/PNF	Stretch Static	Ischemic Comp	Strapping	Other	Referral	Continuation of Play permitted
B 27	3	1	16	2		1	1							1
	3	2	16	2			1							1
	4	3	16	2			1							1
	4	4	16	2			1							1
H 2	7	1	20	2			1							1
	7	2	20	2			1	1						1
M 6	4	1	26	2		1				1				1
	4	2	26	2		1				1				1
	6	3	26	2							1			1
Y 5	4	1	26	2								1		1
	4	2	26	2								1		1
G 7	5	1	31	2			1			1	1			1
	6	2	31	2				1				1		1

The results of Table 21 underscore the fact that at least 44/223 (20%) consultations from 18/153 (12%) athletes resulted in reporting of underlying chronic conditions (the likelihood that this was present prior to participation in the WTG was high), that aggravated with the higher than normal activity levels through the period of the WTG in 2013 (Hyde and Gengenbach, 2007). This implies that these patients formed the core of the “overload” diagnoses (myofasciitis, muscle strains and spasms) and were more likely to present with musculoskeletal compensations and the sequelae of these during increased demand on a physiologically (transplant) and biomechanically (musculoskeletal compensations) compromised body structure (Schonder *et al.,* 2010, Unterman, *et al.,* 2009, Diep *et al.,* 2008; Cavayero and Kar, 2014).

The outcomes of Table 20 and Table 21 are important in the development of injury management and treatment programmes, as these suggest that although injury that is brought into the event may be seen as a relatively large proportion of the injuries that were treated, there is an even larger proportion of injuries that presented at the event or occurred during participation. This implies that the environmental factors as well as the specific physiological limitations of the patients as well as the unique demographic factors of patients and the interaction between these seem to be at least in part responsible for the development of injuries in transplant athletes when they are participating at internationally competitive levels. Therefore injury prevention and management strategies need to consider these aspects of patient / athlete management more seriously in transplant athletes more so than “normal” athletes who may not be as susceptible to the development of these injuries (as they have the ability to physiologically adapt more readily) (Robergs and Roberts, 1996).

4.10 Conclusion

The following conclusions can be drawn regarding the aims and objectives of this study, based on the results obtained and discussed in Chapter Four.

The first objective showed that of the total of 964 registered athletes participating in the WTG, the data from 259 consultations met the inclusion criteria for this research. A total of 223 consultations were made by athletes over the seven days of competition, with the response rate per country (on average) to the presence of the CTF amongst athletes being 15.87%. Furthermore, the data from 36 non-athlete consultations presenting to the CTF met the inclusion criteria for this research.

In terms of the second objective of this research, the profile of the average transplant athlete, voluntarily utilising the CTF at the WTG was the following: a middle aged (± 45 years) White male who is likely to have undergone a kidney transplant. In addition he was likely to have participated in what are considered endurance sports of the WTG and was likely to have suffered an injury to the lower limb, particularly the thigh or shin / calf area and incur an acute injury to the soft tissues of the body. Additionally, less than a third of the presenting athletes (28.3%) would have experienced previous injury, with only 12.6% having experienced previous trauma. Athletes were also at a greater risk of incurring injury as a result of overuse, although the majority of athlete reported injuries were deemed to be of acute clinical impression, with the severity of the injury being significant enough to halt or cease participation or further continuation thereof in only 2% of cases.

In agreement with objective two, objective three provided a treatment profile of modalities utilised in the management of athletes’ injuries whilst attending the CTF. Massage was employed as a treatment modality in more than a third (32.1%) of cases. When cross-tabulated with diagnoses, massage was most commonly utilised in the event of an athlete experiencing myofascial pain and dysfunction / muscular pain or complications. Similarly, when considering injuries sustained to joint or articular structures in the body, it was found that joint manipulation and mobilisation where the most commonly utilised treatment modalities.

In review of the fourth objective of this research project, passive athlete tracking was able to be carried out on 43 athletes, all of whom presented to the CTF on more than a single occasion. The number of cases in which the diagnosis remained constant over a number of consultations was similar to that of the cases in which there was a diagnosis change.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The conclusions made in this chapter arise from a review of the identified outcomes from the collected primary data in this research project. The limitations to this research project are discussed as well. Lastly, the recommendations which follow are made for further studies which can either be directly or indirectly related to this research project and its conclusions. The primary data was collected from the eligible WTG Forms as completed by athletes and non-athletes presenting to the CTF at the 2013 WTG.

5.2 Conclusions

An injury surveillance of patients who utilized the CTF at the 2013 WTG has been described in this research project. The number of athletes who voluntarily sought treatment at the CTF throughout the duration of the 2013 WTG is similar to that as previously recorded at the 2009 WG, and is comparable to the response rates / utilization rates as recorded at other major sporting events.

In review of the objectives outlined for this research project, athletes were shown to make use of the CTF more frequently than non-athletes. Athletes from 29 (60.42%) of the 48 participating nations made use of the CTF on at least one occasion. From a demographic point of view, older white male athletes who had undergone a kidney transplant were the most frequent attendees to the CTF. In terms of profiling the injuries which were encountered at all the CTF over the seven day period of the WTG, it was found that athletes and those who participated in multiple, cross-code sports were the most likely to present to the CTF requiring treatment. Most recorded injuries occurred in the absence of any previous injury or trauma to the specific region of complaint or in general and involved the thigh and / or shin / calf in the majority of cases. Overuse was identified as the main causative mechanism in the large majority of reported injuries, with injuries to the soft tissues of the body being most common, with diagnoses pertaining to muscle tissue injury in particular accounting for more than half of all recorded diagnoses. However, the large majority of injuries sustained were not significant enough in severity to result in an inability for the athlete to either continue play at the time of injury or allow further participation in competition or training post-assessment at the CTF (Only 9 injuries or 3.6%, resulted in an inability to resume or return to competition).

With regard to treatment, there was a total of 521 separate treatment interventions carried out amongst the 223 consultations made by the 153 athletes who sought treatment at the CTF. This correlates into each patient receiving more than one treatment modality at each consultation, of which the most commonly utilized was massage. Ischemic compression and manipulation were the two next most frequently employed treatment modalities, with the high use of massage being attributed to the increased prevalence of muscular injury.

When passive tracking the cohort throughout the duration of the event is analysed, it is noted that only 43 (28.1%) reported to the CTF on more than one occasion.

Collectively when this data is compared to data from other internationally competitive events, the results suggest that the likelihood of injury increases in transplant athletes and that this may be related to the age of the athlete, the type of transplantation (in this study the kidney), the type of event(s) and nature (duration and competitive intensity) of the competition that the athlete participated in as well as the environmental factors surrounding the event. It is therefore important that future events, and the organisers thereof, for transplant athletes that are held in subtropical, humid conditions consider advising their athletes on strategies that would enable them to remain hydrated and adequately prepared for participation and its effects, in order to avoid injury. In addition any medical personnel (chiropractors, physiotherapists, emergency medical personnel, physiotherapists) that are employed to staff medical facilities at such events need to be aware of the fact that simple injuries such as those presenting with muscle injuries, may be precursor events to more serious muscle pathologies (cardiac) and pathologies related to electrolyte and mineral disorders in transplant athletes (particularly in renal transplant patients).Thus there is also a need for a multidisciplinary approach in treating and managing transplant patients and it is important that the various health care providers know and understand their role in relation to the pathogenesis of disease that may be related to transplant patients, the medication that they are required to take and / or the sequelae related to each of these or a combination of them. This would then allow for an effective triage and management system for any patient presenting to any health care provider at venues where transplant patients may present, allowing for effective, optimal and timely care in order to reduce their morbidity and mortality.

5.3 Limitations

Limitations of this study:

- Data recording of clinical information, is a problem for any retrospective study in that the recorded data is finite and no collateral source of information exists to validate or improve the manner in which data is recorded or the type of data that is recorded. Therefore the information presented is limited by that information that exists and the interpretation of the recorded data is based on the premise that the data was collected adequately and accurately. Incomplete or poorly recorded data may influence the results.
- The context in which the data is collected needs to be considered as an influencing factor in the way the data appears in the results. This implies that the following considerations be taken into account as influencers on the outcome of the injury profile:
    - The type or surveillance or recording system.
    - The health care professionals that are responsible for generating the data.
    - The scope of practice of the health care professionals as determined by either their legislated scope of practice in the country or the designated scope of practice within the organisation that is hosting the event.
- In the context of the clinical interaction, the probability of language barriers existing between the presenting athlete or non-athlete, the chiropractic student and the supervising clinician may have been a hindrance in obtaining information from non-English speaking athletes, particularly given that the WTG is a multinational event. These barriers may have proved to be a hindrance to accurately and effectively recording clinical data, as well as to the dispensing of pertinent information to the patient, such as rehabilitative exercises.
- When comparing the data between similar events that have differing research methodologies, data collection procedures, clinical scopes of health care providers and different statistical analyses measures make it difficult to compare results. This is further compounded by the lack of precise definitions of various categories of disease (type, nature, location, chronicity, precursor factors and covariate factors) used when recording or reporting data. Methodologically too, the manner in which injury surveillance studies are carried out varies drastically (prospectively, retrospectively, questionnaires to health care providers, questionnaires to patients), and this too may act as a limitation (Finch, 1997).

- The WTG Form that was utilised in this research project specifies some options for clinical impressions, diagnoses and treatment options (those most commonly encountered), which may have limited the recorded responses by those chiropractic students and their clinicians that aggregated the clinical impressions, diagnoses and treatment options to the closest applicable to the patient / athlete in front of them. It is however not possible to include all options on the WTG Form – viz. the form is not prescriptive in nature, so there was also the option that chiropractic students and their clinicians were able to write their considered clinical opinions without limitation. Therefore it is also possible that the options provided for in this study may be more detailed than other studies where the diagnoses for example are limited by ICD9 or ICD10 clinical codes. Either way, future studies should be carried out with a customised clinical data recording form, but this would be dependent on literature being available for the purpose of being able to construct a form that is either athlete or sports specific. This conundrum will be difficult to overcome no matter how the problem is approached.

5.4 Recommendations for future studies

- The development of data recording forms which would allow for greater specificity in terms of injury profiling could be utilised in future studies to more accurately record information regarding the injuries experienced by transplant athletes.
- Future studies should assess the direct risk factors associated with organ transplantation and athletic involvement and the subsequent risk of injury. This would require prospective, longitudinal studies that track athletes over time as well as the literature identified risk factors so as to determine association and causation.
- Future studies investigating the prevalence of injuries amongst transplant athletes in specific sports should be carried out, as a large majority of athletes competed in multiple sports in the WTG 2013, which may have influenced the data. This is also suggested as the sample sizes per sporting code at the WTG was small and therefore future studies should consider larger sample sizes to be able to more accurately determine association between intrinsic athlete characteristics and injury.
- Future studies investigating the electrochemical changes within muscle tissue pre- and post-exercise should be carried out to assess whether or not solid organ transplantation results in physiological changes in the muscle tissue itself, which may then predispose a transplant athlete to an increased risk of injury.

5.5 Recommendations for clinical practice

- Consideration regarding what transplant a transplant athlete has undergone, as well as what sport it is that they participate in must be taken into account when assessing and treating a transplant athlete.
- The myofascial component of an injury cannot be ignored when treating a transplant athlete, as it could be a precursor for more serious injury / pathology. Thus, care must be taken by those health care providers who deal principally with musculoskeletal structures in the course of their practice (e.g. chiropractors and osteopaths).
- Organisers of sporting events for transplant athletes and the medical personnel employed at these events should be cognisant of the influence that weather conditions and other environmental conditions may have on sport and physical activity participation and prepare the athletes and themselves accordingly.

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Appendix A: WTG Form

World Transplant Games – Durban – South Africa

DUT DURBAN UNIVERSITY OF TECHNOLOGY

By signing alongside this statement, you agree to have the data collected at the WTG in respect of your condition documented in research – without disclosure of your name or identifying details. Sign:______________________Date:___________

Date: 28 29 30 31 July 1 2 3 August 2013 FILE No:____________

NAME: ____

POSITION: ATHLETE (state type: ______________), MANAGE, MEDT OTHER:______________________________

ETHINICTY (stat only): W B IN OTHER:______________AGE:________________________SEX: MALE / FEMALE

TRAVEL HISTORY:____

NEW PATIENT **REPEAT PATIENT**

NEW COMPLAINT **CONTINUATION OF CARE**

REGION OF COMPLAINT

HEAD **NECK** **THORAX** **LUMBAR**

SHOULDER ELBOW WRIST/HAND

FOREARM

UPPER ARM **HIP** **KNEE** **FOOT/ANKLE**

SHIN/CALF **THIGH** **CHEST** **ABDOMEN**

OTHER : state

____

MECHANISM OF INJURY :

____

DID THE INJURY CAUSE THE PATIENT NOT TO PARTICIPATE IN THE EVENT? YES NO

HAS THE AREA BEEN INJURED BEFORE ? YES NO IF SO WHEN:_____________________________

PREVIOUS TRAUMA:

____

CLINICAL IMPRESSIONS: ACUTE CHRONIC

HEAD/CONCUSSION **JNT SPRAIN** **MM STRAIN** **PFPS** **TENDINITIS**

HEAT EXHAUSTION **ABRASION** **CONTUSION** **LACERATION**

C FACET **T FACET** **SI SYNDROME** **L FACET**

MYOFASCIALOF:____

GEN. MUS. TIGHT (DOMS) OF:____

NEURO / SYSTEMIC / OTHER:____

RANGE OF MOTION:____

OTHER:____

DIAGNOSIS

(specific):____

____

____

TREATMENT:

MANIPULATION	**MOBILISATION**	**MASSAGE**	**STRETCH / PNF**
STRETCH (STATIC)	**TENS**	**ISCH COMP**	**REFERAL**

OTHER

____

Indicate specific regions for the modalities

CONTINUATION OF PLAY: YES NO [IF NO - WHY ?____

CLINICIAN :	**STUDENT :**
SIGN :	**SIGN :**

Appendix B: Permission to use data

From: Willie Uys [mailto:willie.uys@wtg2013.com]

Sent: 21 August 2013 06:46 PM

To: 'Charmaine Maria Korporaal'

Cc: 'Heilie Uys'

Subject: RE: Research

Dear Charmaine,

I must firstly apologise for the delay in getting back to you regarding your proposal. Things are a bit crazy trying to wrap things up after the Games and Heilie and I are taking a week-long break from tomorrow so will be cut off from all communication – no cellphones and no Internet.

We would be happy to give permission for the research with the following prerequisites:

1. That you let us have the full copy of the Research Proposal;
2. That we also receive a Summary of the Results &
3. That we receive a Copy of any articles that might be published as a result of the research.

We look forward to hearing about your progress and would also be happy for you to make use of Dr. Heilie Uys as a reference or sounding-board should you need someone like that. I am copying her into this Email so that you will have her details as well.

Just again our sincere appreciation for your wonderful input during the Games.

Yours in Transplant Sports,

WILLIE UYS

SATSA - National Chairman

WTG2013 - Chairman Local Organising Committee

World Transplant Games Federation Councillor

Appendix C: Institutional Research Ethics Committee (IREC) full approval of proposal

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

3 April 2014

IREC Reference Number: **REC 10/14**

Mr M J McBean
30 Glengeni Manor
10 Bradely Road
Durban North
4051

Dear Mr McBean

An injury surveillance of patients utilising the Durban University of Technology (DUT) Chiropractic Treatment Facilities at the 2013 World Transplant Games

I am pleased to inform you that Full Approval has been granted to your proposal REC 10/14.

The Proposal has been allocated the following Ethical Clearance number **IREC 027/14**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC

Appendix D: Plagiarism Declaration

PLAGIARISM DECLARATION

I, ____ (Full name of student) and ________________________________ (full name of supervisor/s), do declare that in respect of the following dissertation/thesis:

____
____
____
____

As far as we know and can ascertain: (√ appropriate answer)

a. No other similar dissertation/thesis exists

b. The only similar dissertation/s thesis/es that exist/s is/have been referenced in my dissertation as follows:

____
____
____
____

1. I know and understand that plagiarism is using another person's work and pretending it is one's own, which is wrong.
2. This dissertation/thesis/essay/report/project is my own work.
3. All references as detailed in the dissertation are complete in terms of all personal communications engaged in and published works consulted.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

____

Signature

____

Name (in capital letters)

____

Student Number